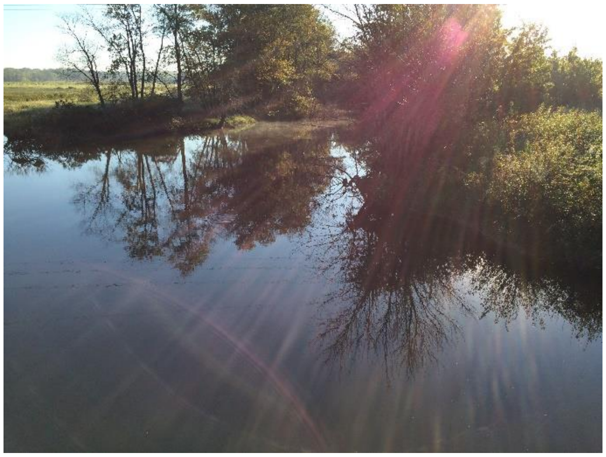


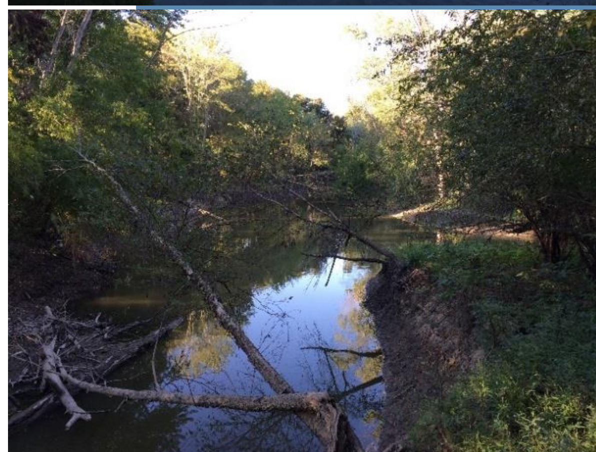

Watershed Implementation Plan

To Achieve the TMDLs and Load Reduction Strategy in the Upper Big Muddy River Watershed

Prepared for:
Illinois EPA

DRAFT for Public Comment

October 15, 2018

LimnoTech

Water Environment | Scientists Engineers

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Watershed Implementation Plan To Achieve the TMDLs and Load Reduction Strategy in the Upper Big Muddy River Watershed

Prepared for:
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1 Introduction to the Implementation Plan

The Upper Big Muddy River watershed is located in southern Illinois, in Franklin, Jackson, Williamson and Hamilton Counties. The watershed study area is approximately 313,435 acres (490 mi^2) in size, but this area does not include drainage areas upstream of Rend Lake Dam. The impaired reach of the main stem of the Upper Big Muddy begins at Rend Lake Dam and extends approximately 48 miles downstream (waterbody segments IL_N-06, IL_N-11, and IL_N-17). Major tributaries include: Middle Fork Big Muddy River (waterbody segments IL_NH-06 and IL_NH-07) and Pond Creek (waterbody segment IL_NG-02).

This watershed implementation plan was prepared to document the conditions causing water body impairments and the plan to address those impairments. Specifically, the plan is intended to address only those impairments identified in the State of Illinois 2012-2016 Integrated Water Quality Report and Section 303(d) List, and refined based on the findings discussed in the Stage 3 report. Figure 1 shows a map of the watershed and includes some key features such as waterways, subwatersheds, and the waterbodies with TMDLs or LRSs to be implemented under this plan The TMDL and LRS development process and results for the Upper Big Muddy River watershed waterbodies are documented in the Upper Big Muddy River Watershed Stage 3 TMDL Report. The waterbody segments within Upper Big Muddy River Watershed with TMDLs and LRSs developed as a part of this project are shown in Table 1-1.

Table 1-1. Waterbody TMDL/LRS Summary

Waterbody/ Segment ID	Size (mile/ac)	Impaired Designated Use	Impairment Cause	TMDL or LRS?
Big Muddy R. / IL_N-06	15.13 mi	Aquatic life	Sedimentation/Siltation	LRS
Big Muddy R. / IL_N-11	11.48 mi	Primary contact recreation	Fecal Coliform	**TMDL**
		Aquatic life	Sedimentation/Siltation, TSS	LRS
Big Muddy R. / IL_N-17	21.48 mi	Aquatic life	Sedimentation/Siltation, TSS	LRS
Andy Cr. / IL_NZN-13	11.7 mi	Aquatic life	Iron	**TMDL**
Herrin Old / IL_RNZD	51.3 ac	Aesthetic Quality	Phosphorus (Total)	**TMDL**
Pond Cr. / IL_NG-02	23.53 mi	Aquatic life	Sedimentation/Siltation	LRS
Lake Cr. / IL_NGA-02	12.33 mi	Aquatic life	Dissolved Oxygen	**TMDL**
Beaver Cr. / IL_NGAZ-JC-D1	1.7 mi	Aquatic life	Manganese	**TMDL**
Johnston City / IL_RNZE	64 ac	Aesthetic Quality	Phosphorus (Total)	**TMDL**
Arrowhead (Williamson) / IL_RNZX	30 ac	Aesthetic Quality	Phosphorus (Total)	**TMDL**
M. Fk. Big Muddy / IL_NH-06	12.52 mi	Primary contact recreation	Fecal Coliform	**TMDL**
M. Fk. Big Muddy / IL_NH-07	19.74 mi	Aquatic life	Sedimentation/Siltation	LRS
West Frankfort Old / IL_RNP	146 ac	Aesthetic Quality	Phosphorus (Total)	**TMDL**
West Frankfort New/IL_RNQ	214 ac	Aesthetic Quality	Phosphorus (Total)	**TMDL**

As described in the Stage 3 report, TMDLs and Load Reduction Strategies were calculated for each impaired lake and stream segment. Some of the impaired streams and lakes with TMDLs had permitted points sources noted as a source of the impairments, and included required waste load allocations. These water bodies are shown in Table 1-2.

Table 1-2. TMDLs with Point Source Wasteload Allocations

Waterbody/ Segment ID	Impairment Cause	NPDES Facilities with WLAs
Lake Cr. / IL_NGA-02	Dissolved Oxygen	IL0029301 (Johnston City STP)
West Frankfort New/IL_RNQ	Phosphorus (Total)	IL0072478 (Village of Thompsonville STP)

It is anticipated that those TMDLs that require reductions to the WLAs for point sources will be addressed through the NPDES permit process by the Illinois EPA permits section during the next cycle of permit renewal. The source of the impairment for Lake Creek (IL_NGA-02) was identified as being primarily from a point source, so there are no plans for implementation of management measures for non-point sources in this plan. West Frankfort New reservoir (IL_RNQ) has both non-point source and point source pollutant load reductions required to meet the TMDL, and the recommendations for implementation measures to address non-point sources are identified in this plan.

It is important to note that this watershed implementation plan is specifically intended to address excess pollutant loadings identified above and is not intended to address other watershed conditions that may exist in the Upper Big Muddy River watershed. A comprehensive watershed characterization was developed and is presented in Section 2 of this plan, which provides a solid baseline of relevant information necessary to understand the sources of identified impairments and identify appropriate and effective actions to address them. Sections 3 through 7 are organized and written to address the nine key watershed plan elements identified by USEPA in the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* for achieving improvements in water quality (USEPA, 2008).

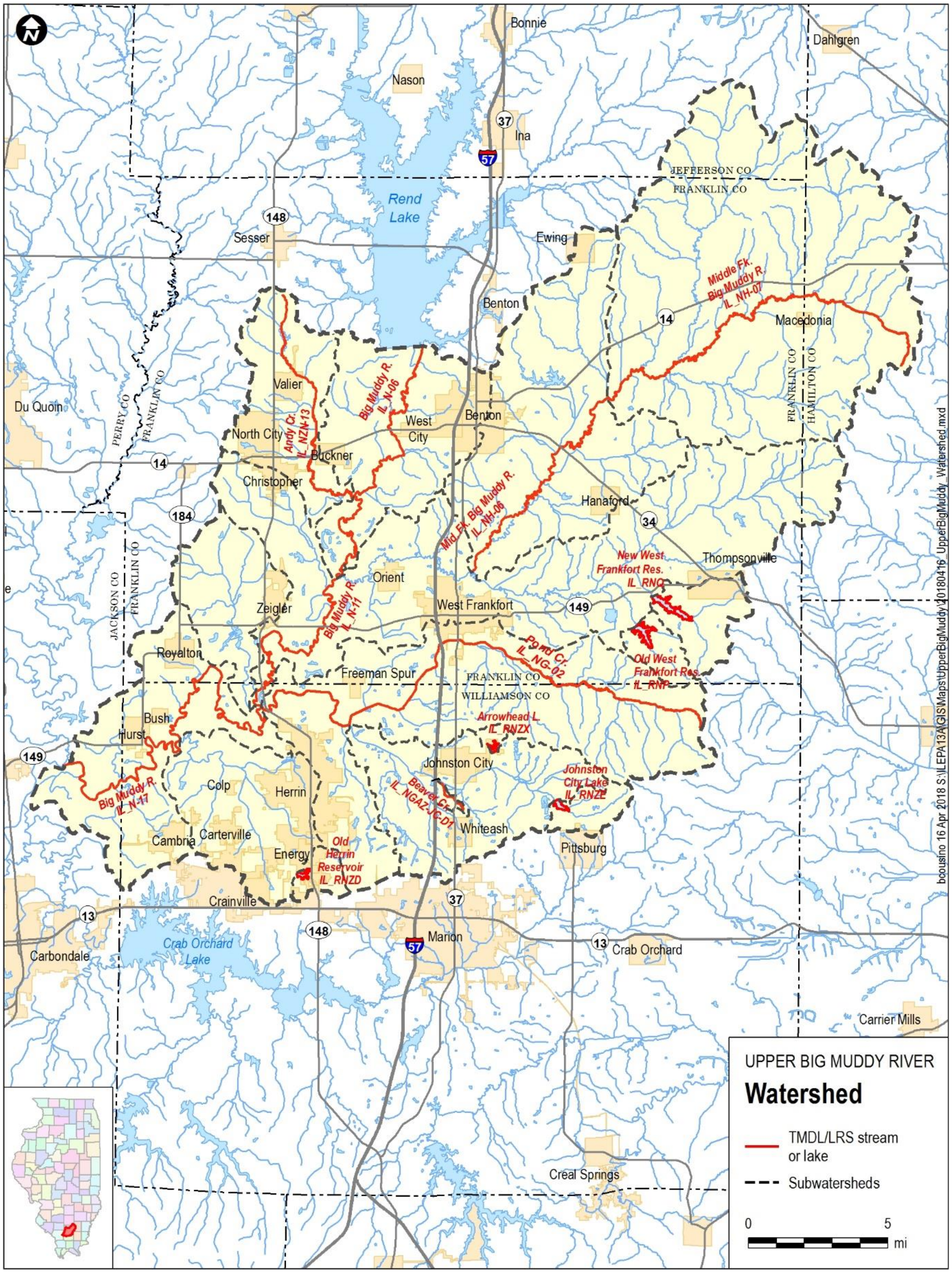

Figure 1-1. The Upper Big Muddy River Watershed, Showing Waterbodies with TMDLs or LRSs

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2 Watershed Characterization

As stated in Section 1, this implementation plan was prepared to address excess phosphorus, fecal coliform, sediment, iron, and manganese in the several waterbodies throughout the Upper Big Muddy River watershed. The sections that follow provide a broad overview of the characteristics of the Upper Big Muddy River watershed to inform the pollutant source identification, and selection of management practices to control the pollutants.

2.1 Watershed Boundaries and Geographic Focus of the Plan

The Upper Big Muddy River watershed is located in southern Illinois, in Franklin, Jackson, Williamson and Hamilton Counties (Figure 2-1). The watershed study area is approximately 313,435 acres (490 mi^2) in size, but this area does not include drainage areas upstream of Rend Lake Dam. The impaired reach of the main stem of the Upper Big Muddy begins at Rend Lake Dam and extends approximately 48 miles downstream (IL_N-06, IL_N-11, and IL_N-17). Major tributaries include: Middle Fork Big Muddy River (units IL_NH-06 and IL_NH-07) and Pond Creek (IL_NG-02).

2.2 Watershed Characteristics

The Upper Big Muddy River watershed was characterized by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, local agencies were contacted to obtain information on cropping practices, tillage practices and best management practices (BMPs), and other land uses employed.

After the watershed boundaries for the impaired waterbodies in the project watershed were delineated from topographic and stream network (hydrography) information, other relevant information was obtained. This spatial information was supplemented from various other publicly available sources. The following watershed characteristics are described in this section:

- Topography
- Climate and Hydrology
- Geology
- Soils
- Demographics and Urbanization
- Land Cover

2.2.1 Topography

The Upper Big Muddy River watershed is generally flat, with gentle slopes in the headwaters. The highest elevations in the watershed (about 610 feet) are found west of Akin in Hamilton County. The lowest elevation (about 380 feet) in the watershed occurs at the outlet near De Soto in Jackson County. A topographic map of the watershed is presented as Figure 2-2.

Slopes in the Upper Big Muddy River watershed range from 0% to 115%, with an area-weighted average slope of 2.9%. A topographic map of the watershed is presented as Figure 2-2.

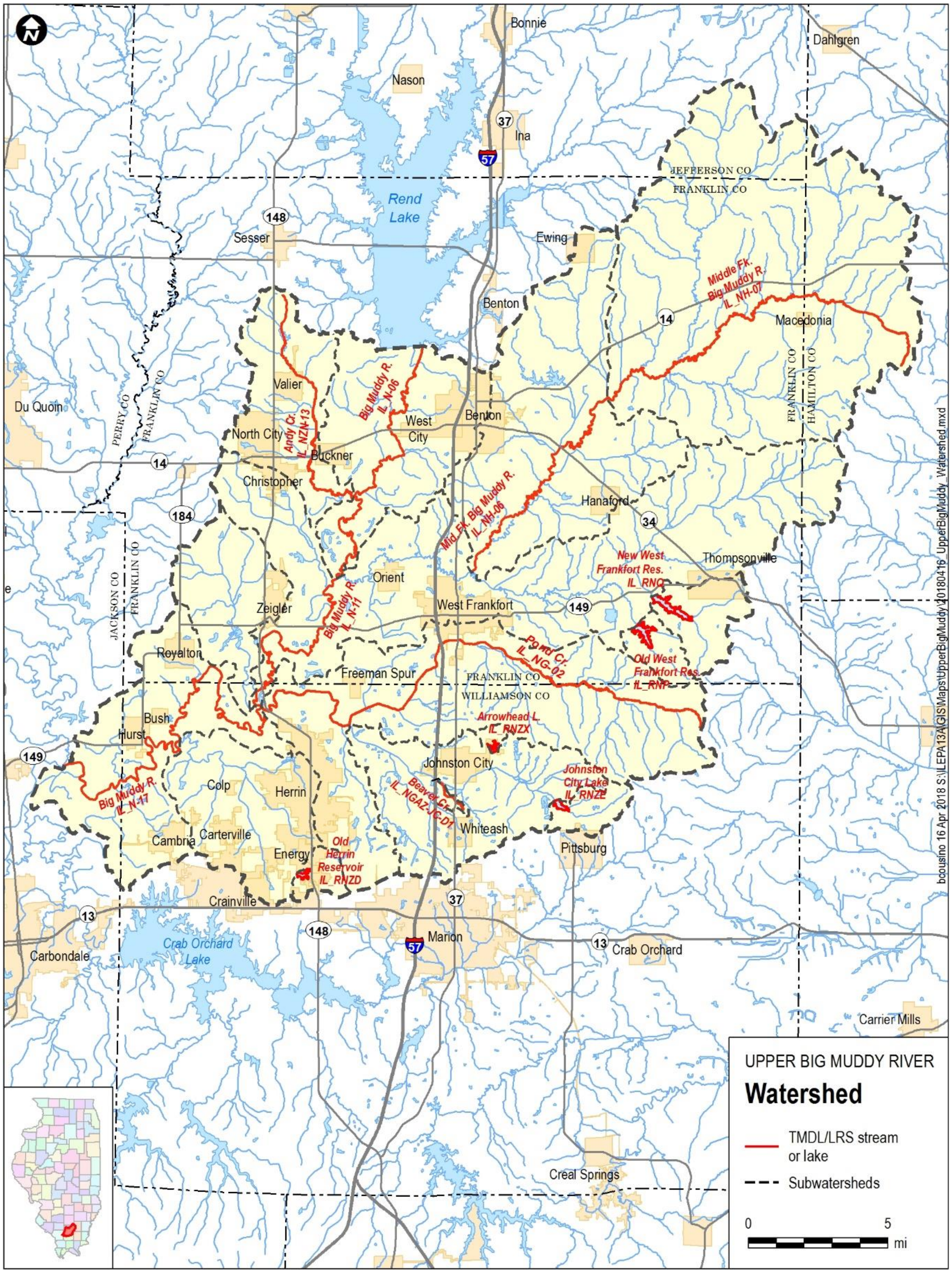


Figure 2-1. Upper Big Muddy River Watershed

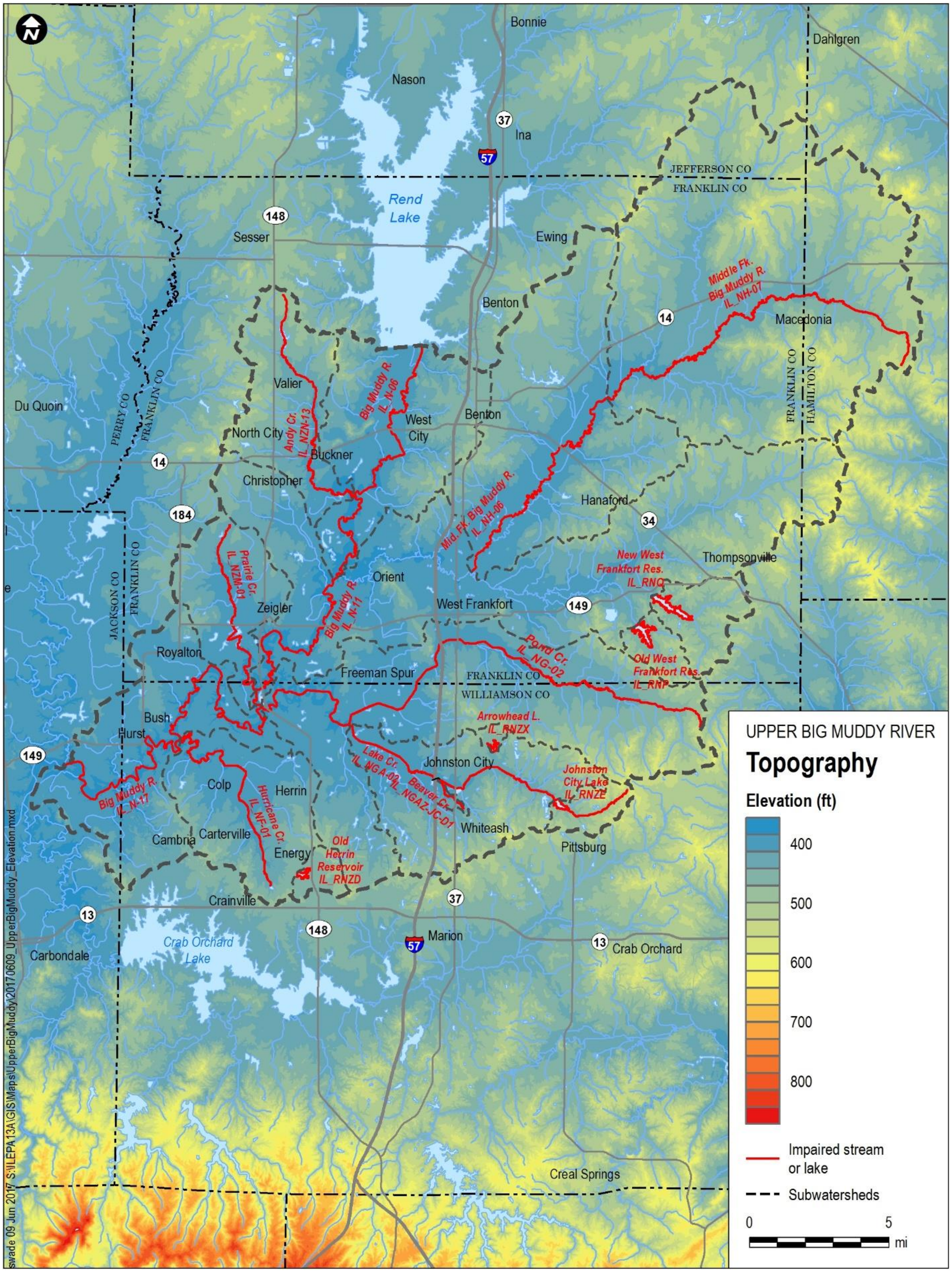


Figure 2-2. Topography of the Upper Big Muddy River Watershed

2.2.2 Climate and Hydrology

The Upper Big Muddy watershed has a continental climate with cold winters and hot, humid summers. The National Weather Service (NWS) maintained a weather station in the watershed at Benton, Illinois that closed in February 2009. Benton is relatively near the center of the targeted watershed and is a reasonable approximation of climate in the watershed.

Precipitation data from 1912 through station closure were downloaded and summarized (Table 2-1, Figure 2-3). The 96 years of historical precipitation data for Station 110608 in Benton average 40.5 inches of precipitation each year. The highest monthly average is May, with a long-term average of 4.2 inches of precipitation. The lowest monthly average occurs in February (2.6 inches). The most intense storms, based upon the daily maximum precipitation, may come during spring, summer or fall; precipitation events are typically milder during winter.

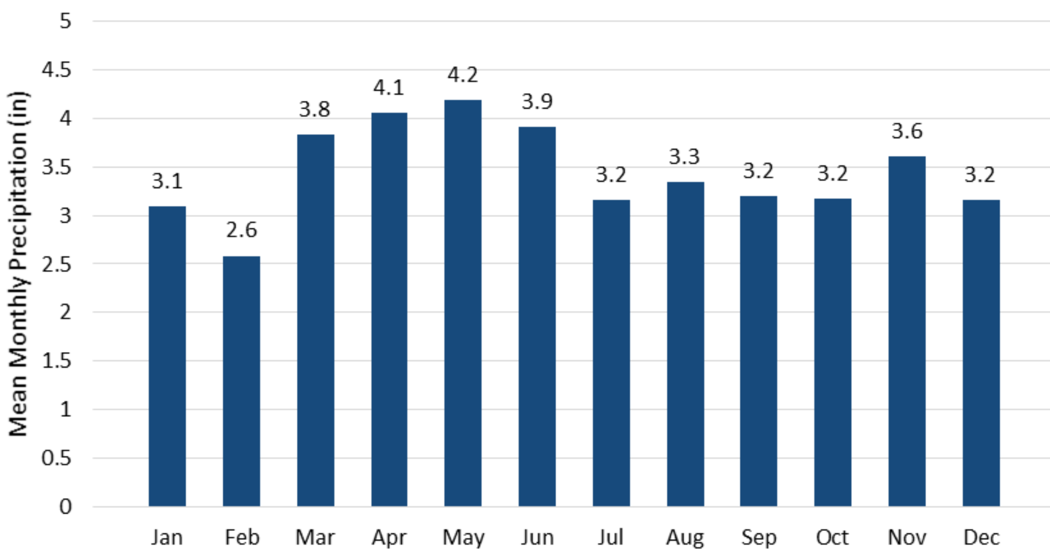


Figure 2-3. Average Monthly Precipitation in the Upper Big Muddy River Watershed

Air temperature data from the entire period of record were downloaded and summarized as well. The monthly mean, low, and high temperature data is reported for 1902 – 1920, 1976 – 1979, and 1998 – 2009, with limited or no reporting in between. The average air temperature data from the periods reported at this gage is summarized in Figure 2-4.

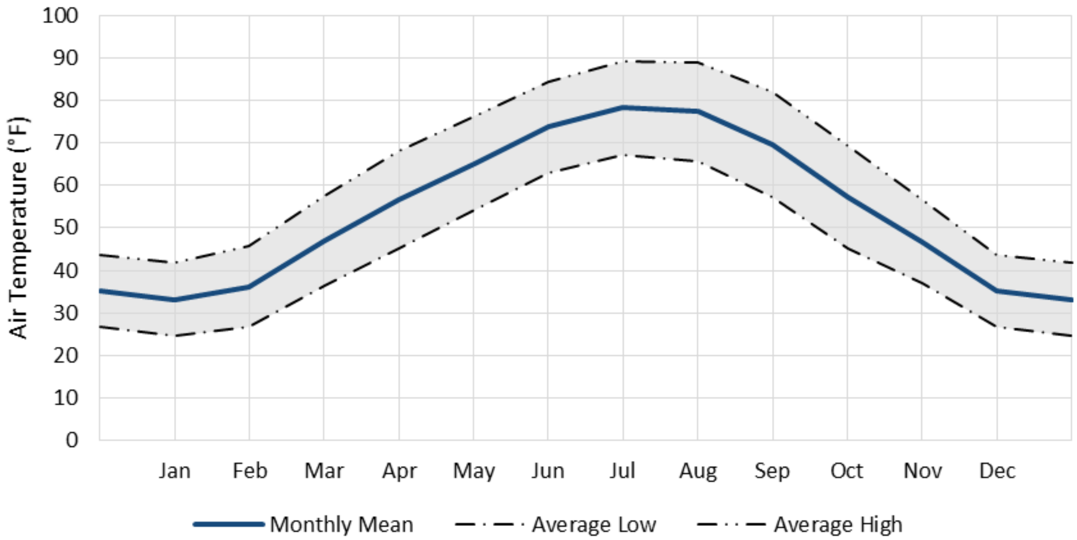


Figure 2-4. Average Monthly Air Temperature in the Upper Big Muddy River Watershed

Table 2-1. Long-term Precipitation Statistics for Benton, Illinois

Month/Season	Precipitation (in)	Days of Rain	Max Daily Precipitation (in)
1	3.1	8	1.2
2	2.6	7	1.0
3	3.8	9	1.3
4	4.1	9	1.4
5	4.2	9	1.4
6	3.9	8	1.4
7	3.2	7	1.3
8	3.3	6	1.4
9	3.2	6	1.4
10	3.2	7	1.3
11	3.6	7	1.4
12	3.2	8	1.2
Spring	12.0	26	2.0
Summer	10.3	21	2.1
Fall	9.8	20	2.0
Winter	8.8	22	1.8
Annual	40.5	89	3.1

Source: Downloaded from http://www.isws.illinois.edu/data/climatedb/choose.asp?stn=110608

There is an active USGS streamflow gage in the watershed, located on the Big Muddy River at Plumfield, Illinois where State Highway 149 crosses the river (gage 05597000). The gage is about 1.9 miles downstream from the confluence with the Middle Fork Big Muddy River. The drainage area at this gage is 792 square miles and daily discharge measurements are available from 1908 to present.

Hydrology of the river has been significantly altered since the construction and filling of the Rend Lake Dam in the early 1970s. Maximum recorded discharge before Rend Lake Dam construction is 42,900 ft^3/s on May 10, 1961. There was no flow at times in 1908-9, 1914, 1936, and 1940-41. Maximum recorded discharge since construction of Rend Lake is 14,200 ft^3/s on May 1, 1996. The minimum discharge since construction of Rend Lake is 6.8 ft^3/s on Oct. 13, 1970. Average daily flow over the past 42 years is 735 ft^3/s.

Flow durations represent the percentage of time that a specified streamflow is equaled or exceeded during a given period. Figure 2-5 is a flow duration curve for USGS gaging station 0559700. Such analyses are a summary of the past hydrologic events (in this case, daily discharge). And if the streamflow during the period for which the duration curve is based is a sufficiently long period of record, the statistics can be used as an indicator of probable future conditions. Figure 2-5 illustrates the tremendous effect that Rend Lake has had on the hydrology of the Big Muddy River. It has significantly altered the hydrology, generally reducing the highest flows with the flow attenuation storage that is provided by the dam, and increasing the lower flow encountered with controlled flow release from Rend Lake.

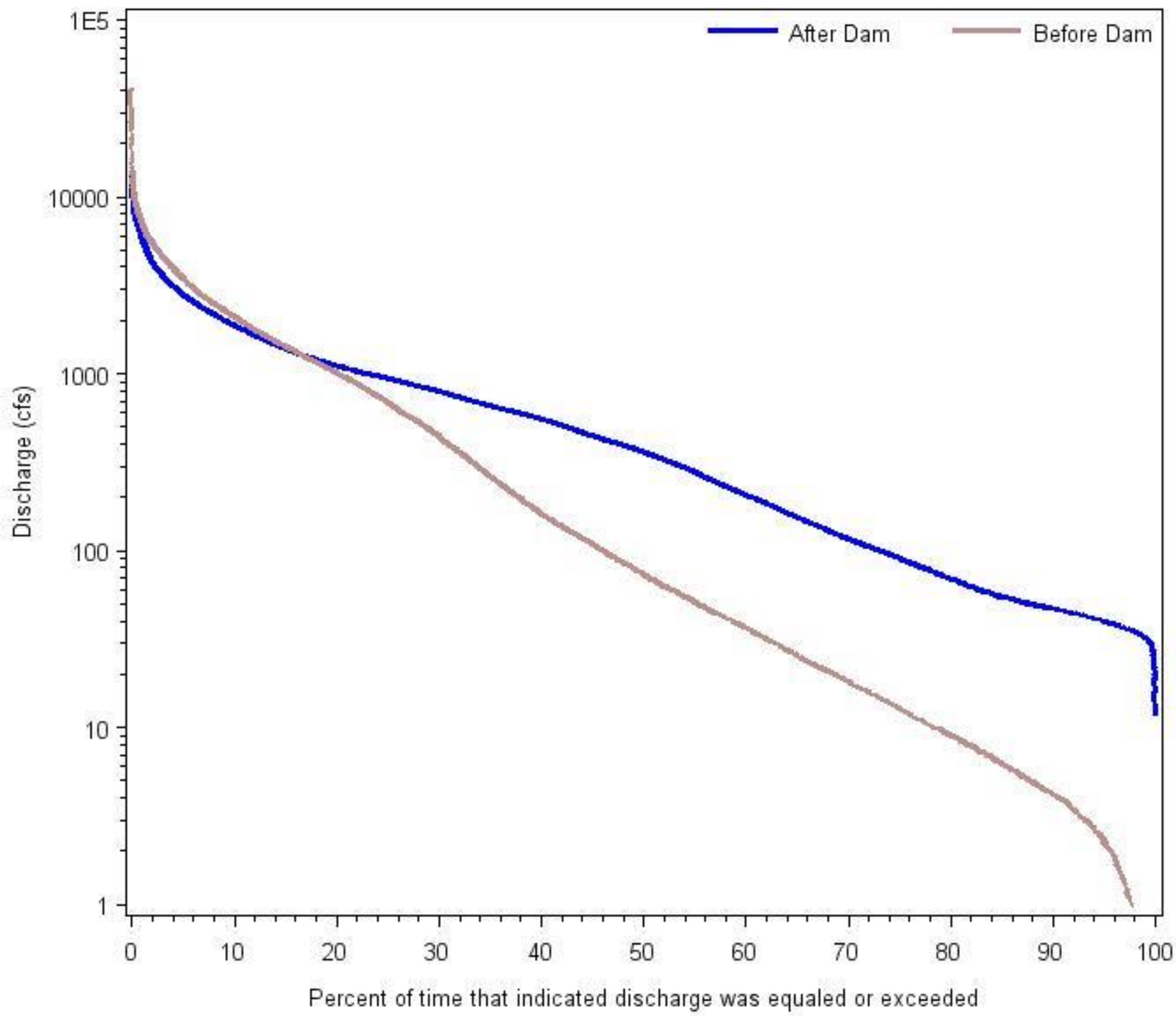


Figure 2-5. Flow Duration Curve, USGS Station 05597000, Big Muddy River at Plumfield, IL, Before and After Dam Construction

2.2.3 Geology

Bedrock geology in the Upper Big Muddy River watershed is a mixture of (60.6%) Pennsylvanian shale and Pennsylvanian limestone (39.4%) formations (Figure 2-6).

Surface geology of the Upper Big Muddy River watershed, like most of Illinois, is dominated by glacial drift. Glacial drift thickness is variable within the watershed, ranging from less than 25 feet to 200 feet (see Figure 2-7). The majority of the watershed (52%) has glacial drift thickness less than 25 feet, generally located in the upland areas. There are bedrock valleys that underlie the major drainage courses within the watershed, although the present streams channels do not always align with the bedrock valleys. These areas contain thicker unconsolidated glacial deposits, with 24.8% of the watershed area containing 25 to 50 feet of glacial drift, and 22.2% of the watershed with glacial drift thickness of 50-100 feet. Less than 1% of the watershed has glacial drift more than 100 feet thick, and those areas are located in the southern portion of the watershed in Williamson and Jackson Counties.

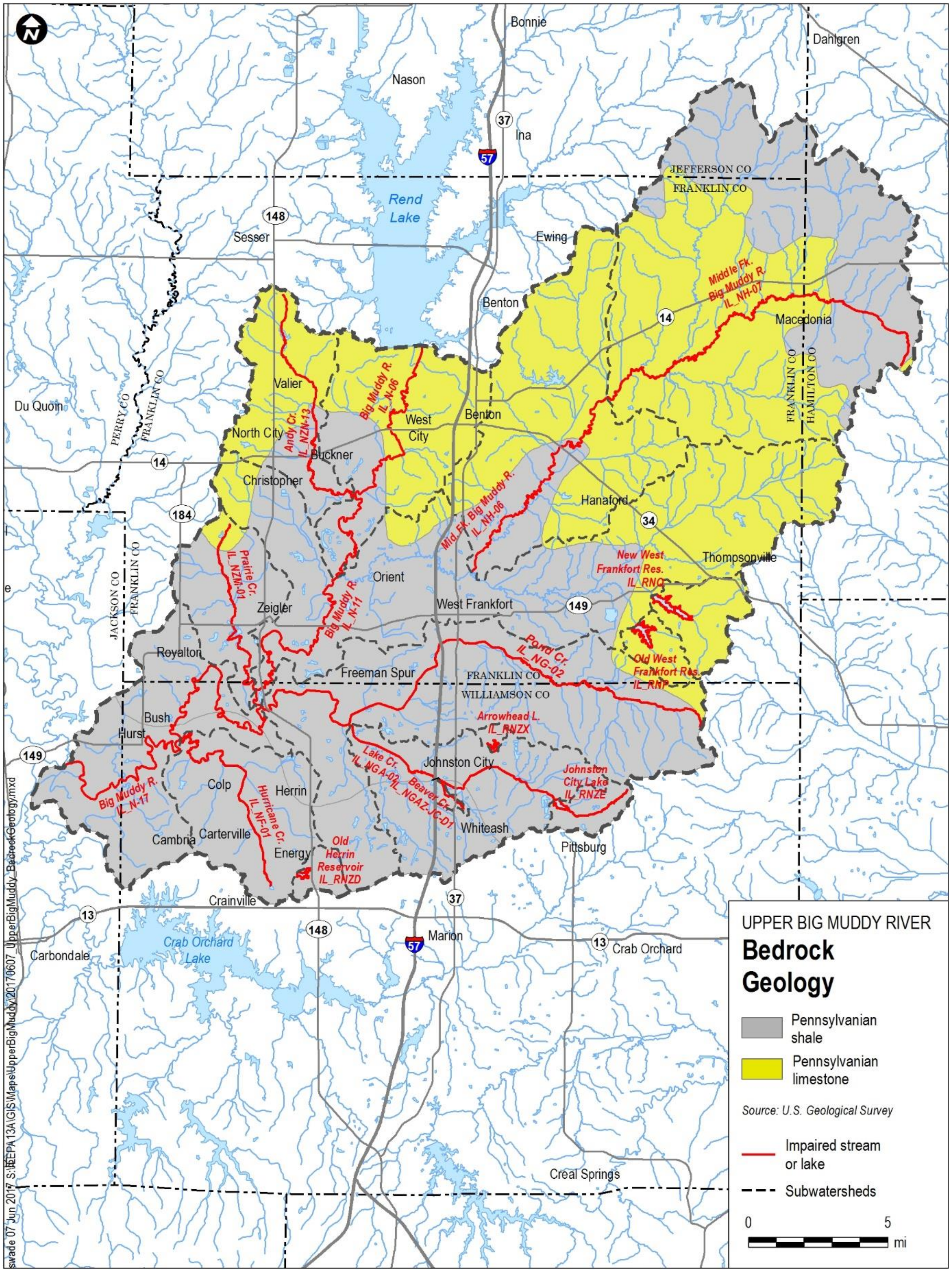


Figure 2-6. Geologic Units in the Upper Big Muddy River Watershed

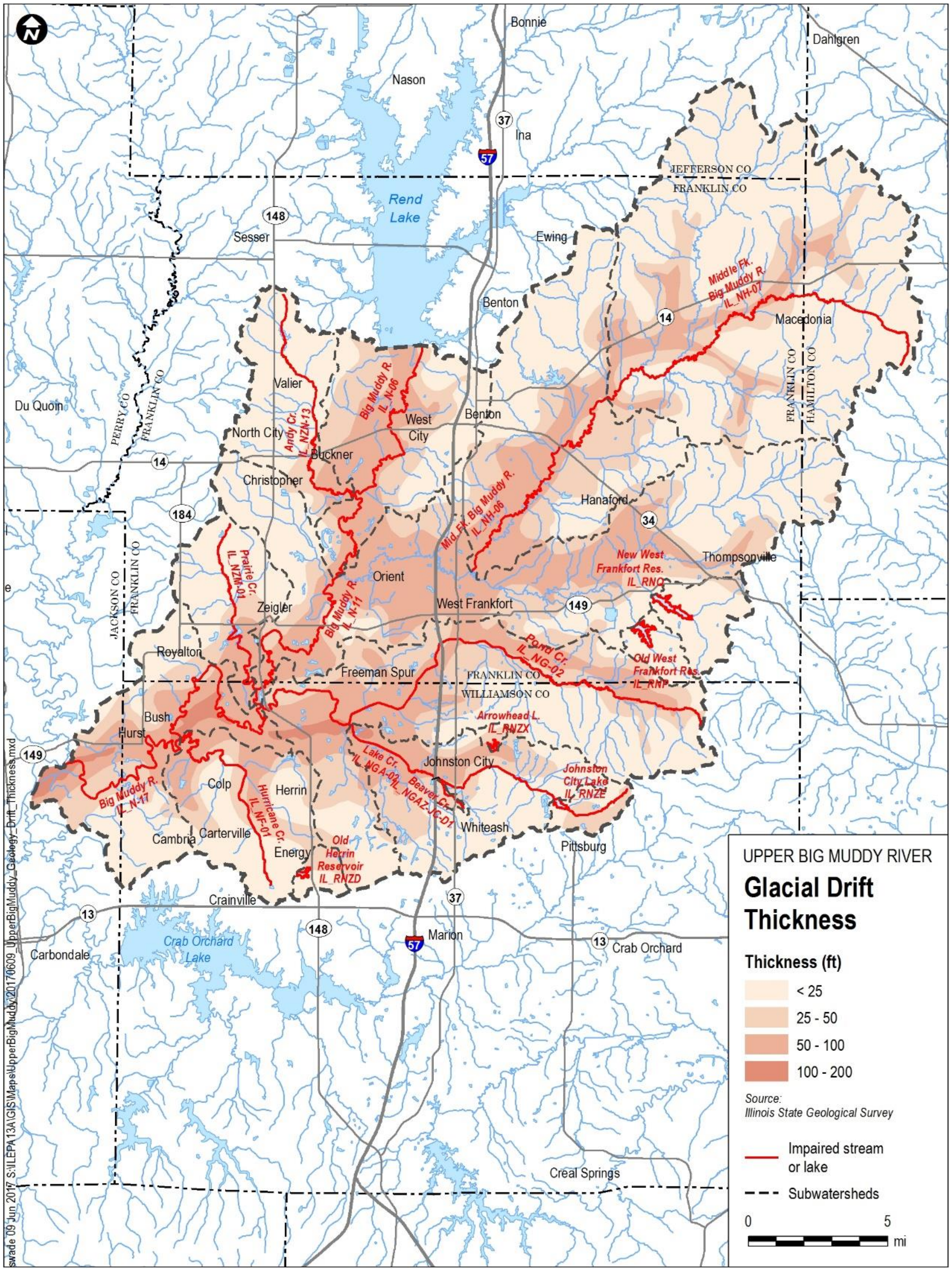


Figure 2-7. Glacial Drift Thickness in the Upper Big Muddy River Watershed

2.2.4 Soils

Together with topography, the nature of soils in a watershed play an important role in the amount of runoff generated and soil erosion. The Natural Resources Conservation Service's (NRCS) Soil Survey Geographic (SSURGO) database was reviewed to characterize study area soils. The target watershed has rich silt loam soils, lying predominately on slopes less than 2%. The most common soil types in the watershed are silt loam (78%) and silty clay loam (15%). The remaining soil types occur in much smaller percentages in the watershed. Soil texture distribution is shown in Figure 2-8 and a map of soil texture classes in the Upper Big Muddy River watershed is shown in Figure 2-10.

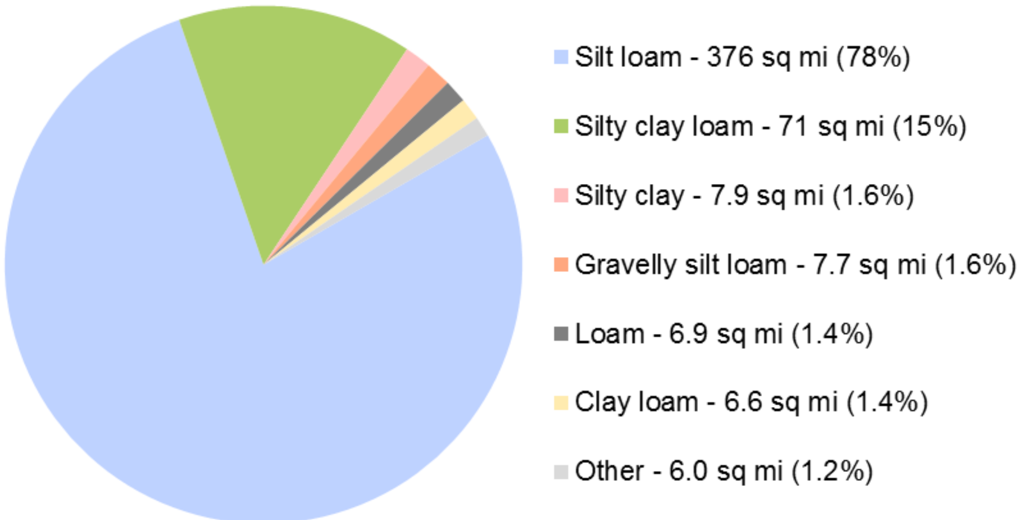


Figure 2-8. Distribution of Soil Texture Classes in the Upper Big Muddy River Watershed

The most predominant hydrologic soil group is C (49.7%), followed by D (24.4%), and soils that are C when drained, D when not drained (11.6%). 14.2% of the watershed soils are hydrologic soil group B and B/D (Figure 2-9). Approximately 2.6% of the HSG in the watershed are not classified. Those are primarily associated with water, urban, and mine dump map units. Hydrologic soil groups are mapped in Figure 2-11.

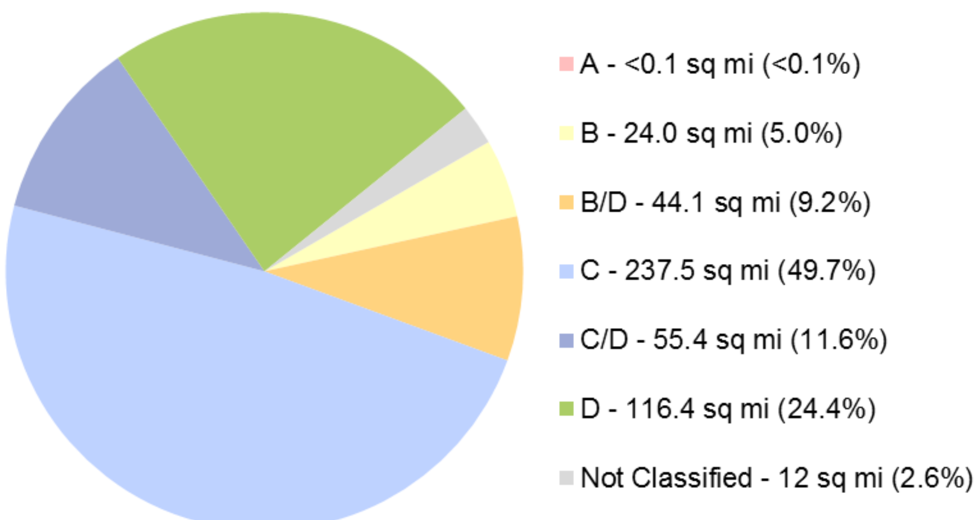


Figure 2-9. Distribution of Hydrologic Soil Groups (HSG) in the Upper Big Muddy River Watershed

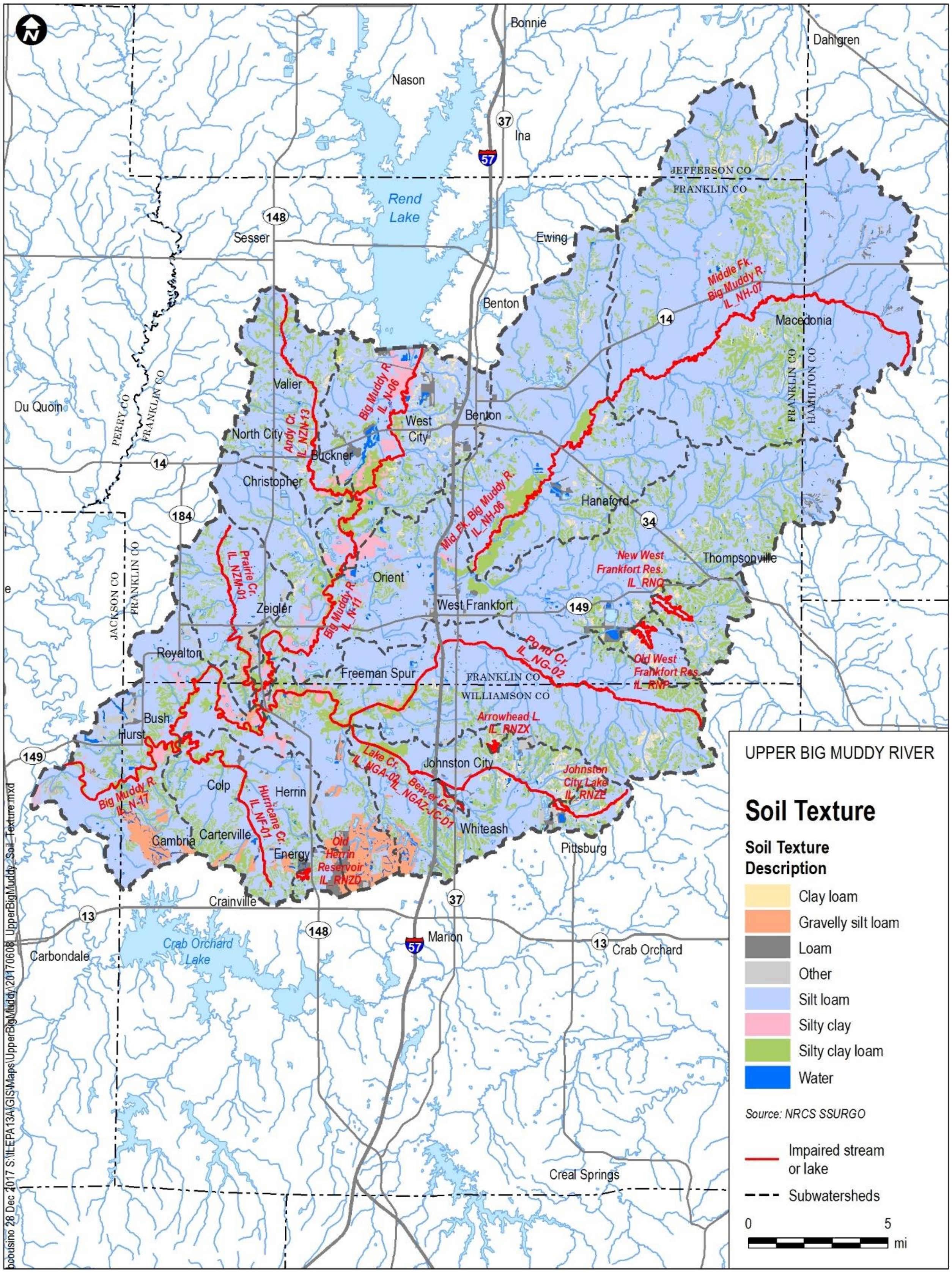


Figure 2-10. Soil Texture Classes in the Upper Big Muddy River Watershed

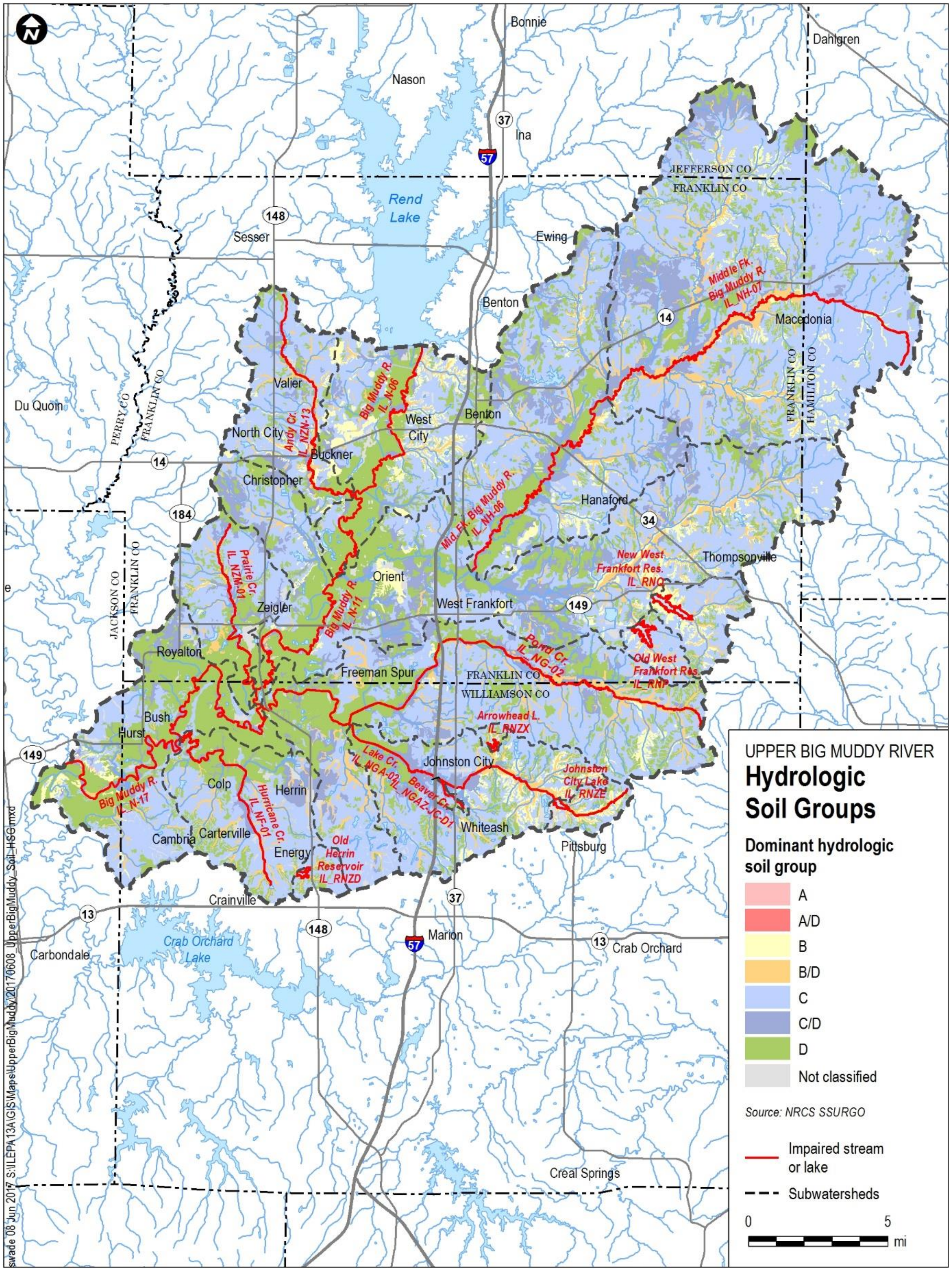


Figure 2-11. Hydrologic Soil Groups in the Upper Big Muddy River Watershed

The preceding discussion of topography, soil texture and hydrologic soil group classifications paint a picture of a watershed with steeper slopes near the headwaters, and flatter regions farther downstream, with poorly to very poorly drained soils dominating. According to soil drainage classification by the Natural Resource Conservation Service (NRCS, Figure 2-12), 13% of soil in the Upper Big Muddy River watershed is classified as "very poorly drained" or "poorly drained", with another 46% classified as "somewhat poorly drained". 27% of soil in the watershed is classified as "well drained" or "moderately well drained".

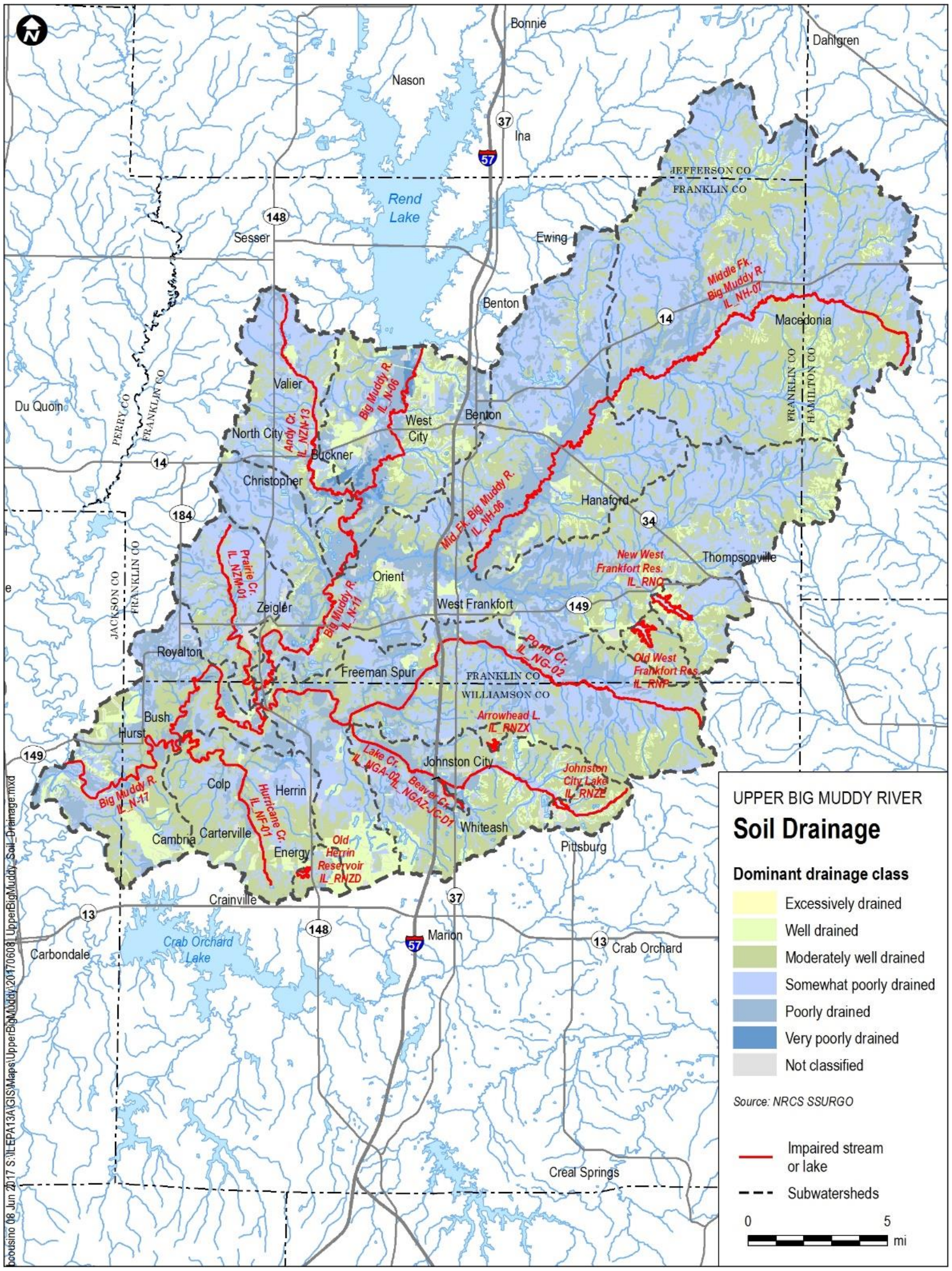


Figure 2-12. Soil Drainage Classification in the Upper Big Muddy River Watershed

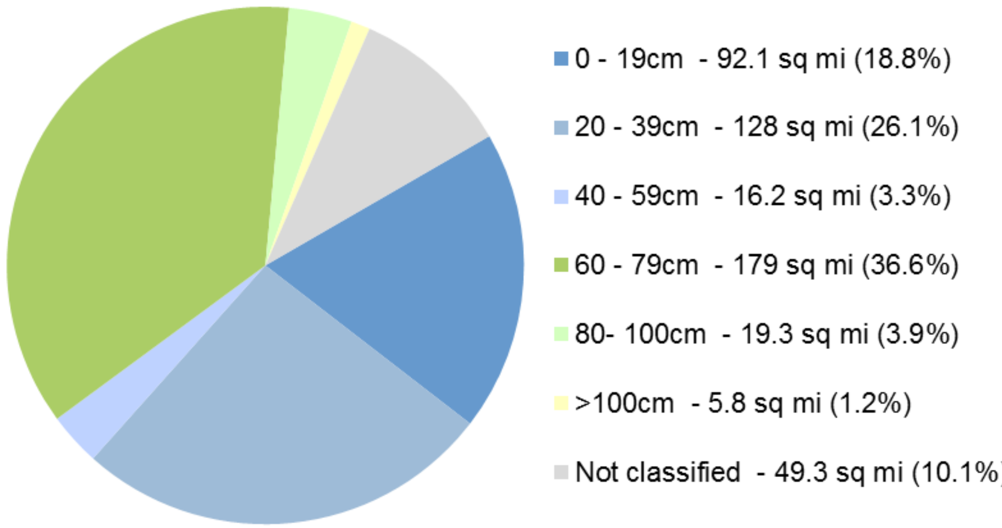


Figure 2-13. Depth to Groundwater in the Upper Big Muddy River Watershed

Groundwater in some areas of the watershed is very shallow (Figure 2-13 and Figure 2-14), with 18.8% of the watershed having an annual minimum water table depth of 15 cm (~6 inches). Overall, 88% of the watershed has an annual minimum water table depth of 79 cm (~31 in.) or less. Furthermore, 19% of the soils in the watershed are classified as hydric (Figure 2-15). These conditions suggest that roughly a fifth of the Upper Big Muddy River Creek watershed may have been covered by wetlands in the past. Based on recent land cover data (Illinois Cropland Data Layer 2011), there is less than 1% of the watershed that is currently covered with wetlands.

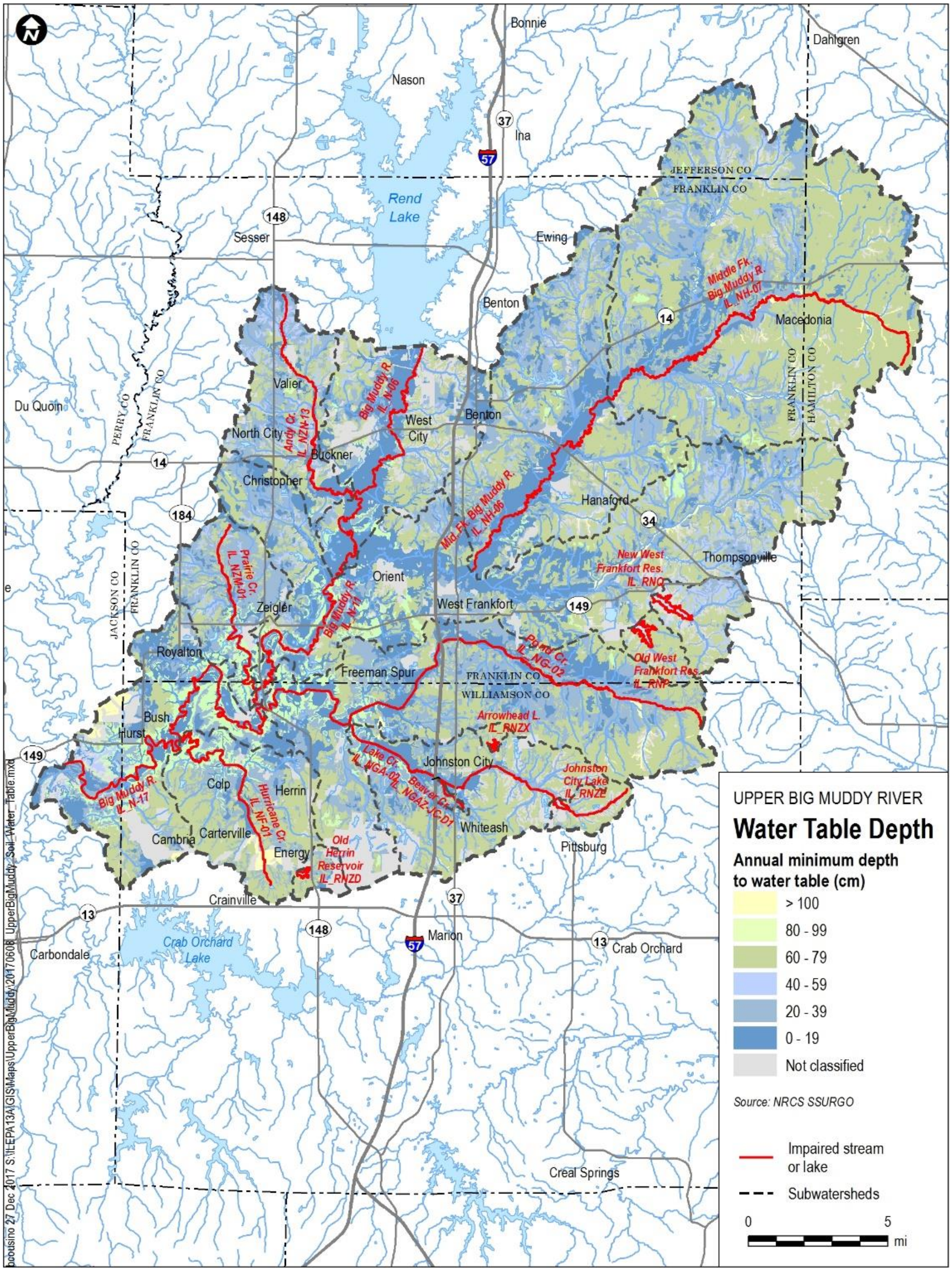


Figure 2-14. Depth to Groundwater in the Upper Big Muddy River Watershed

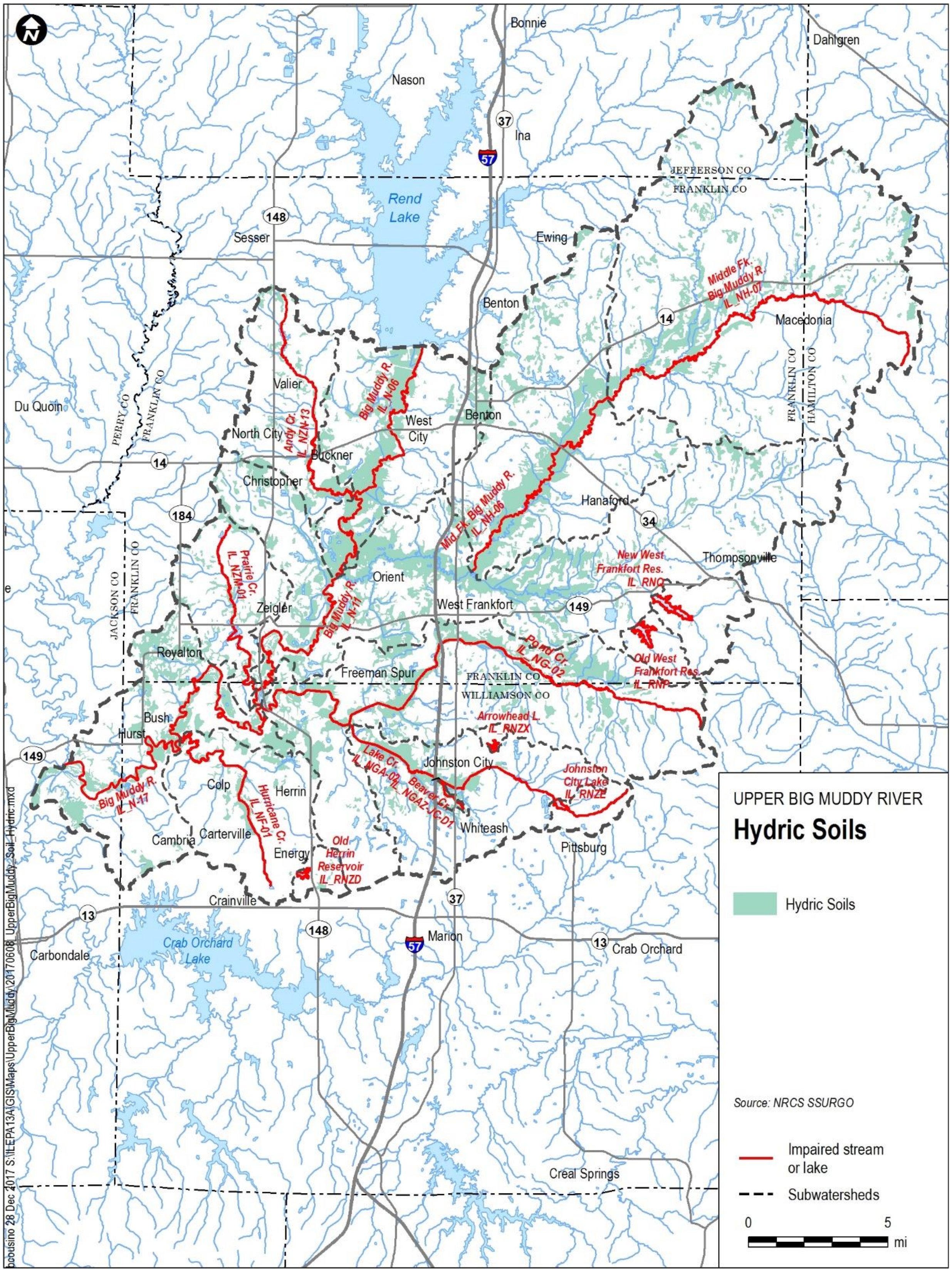


Figure 2-15. Hydric Soils in the Upper Big Muddy River Watershed

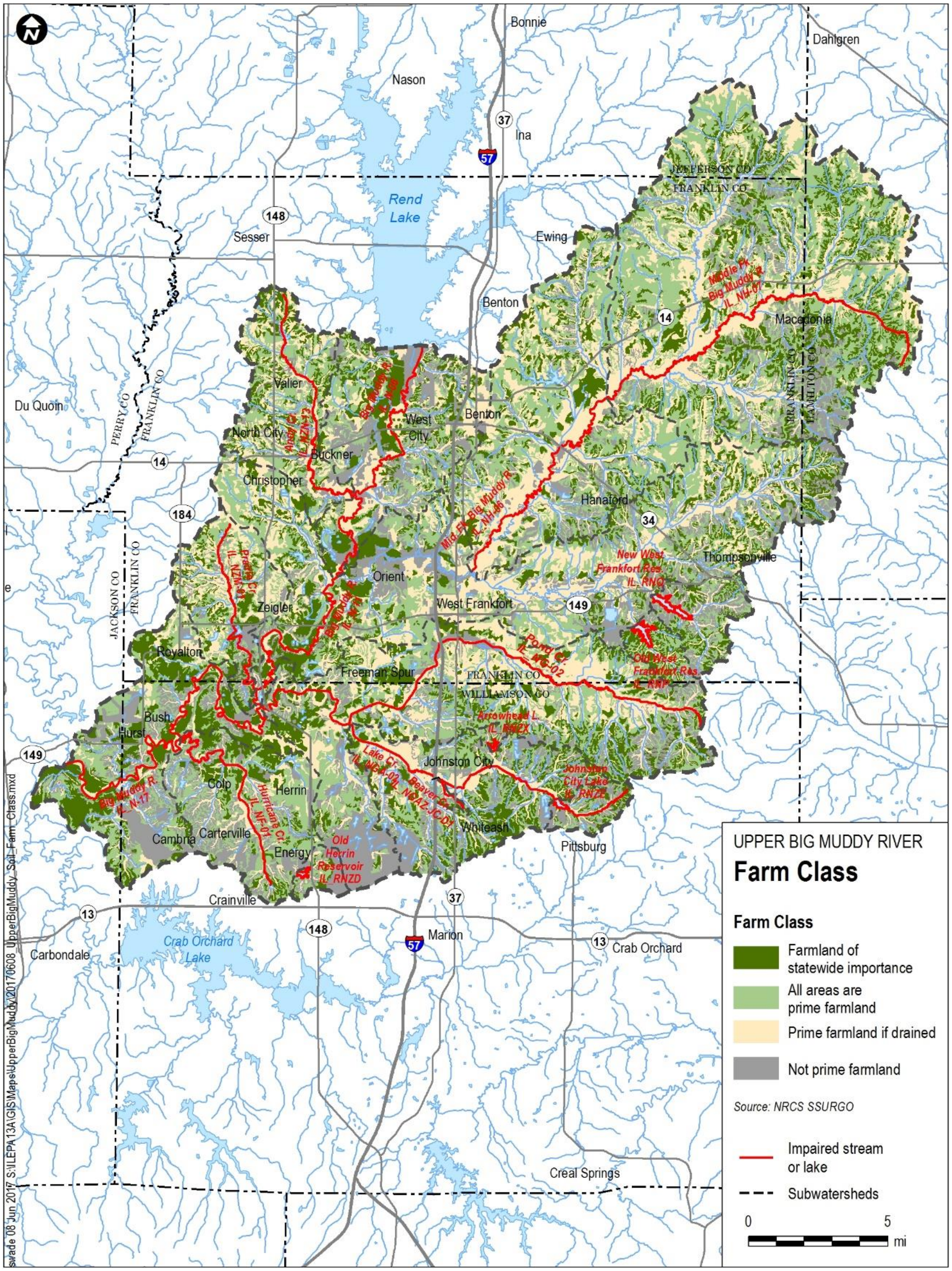


Figure 2-16. Farmland Quality in the Upper Big Muddy River Watershed

The NRCS classifies the agricultural quality of soils and 30.9% of the Upper Big Muddy River watershed is classified as "prime farmland if drained" or "prime farmland if drained and either protected from flooding or not frequently flooded during the growing season". 20.3% is classified as farmland of statewide importance. Another 30.6% of the watershed is classified as "prime farmland" and 18.1% is classified as "not prime farmland" (Figure 2-16).

76.7% of soil in the Upper Big Muddy River watershed is classified as having high erodibility and 20.9% is classified as having moderate erodibility (Figure 2-17). None of the soils with erodibility classifications within the watershed were classified as low erodibility. 2.5% of the areas within watershed were unclassified, primarily areas that were urban land, mine dumps, or water.

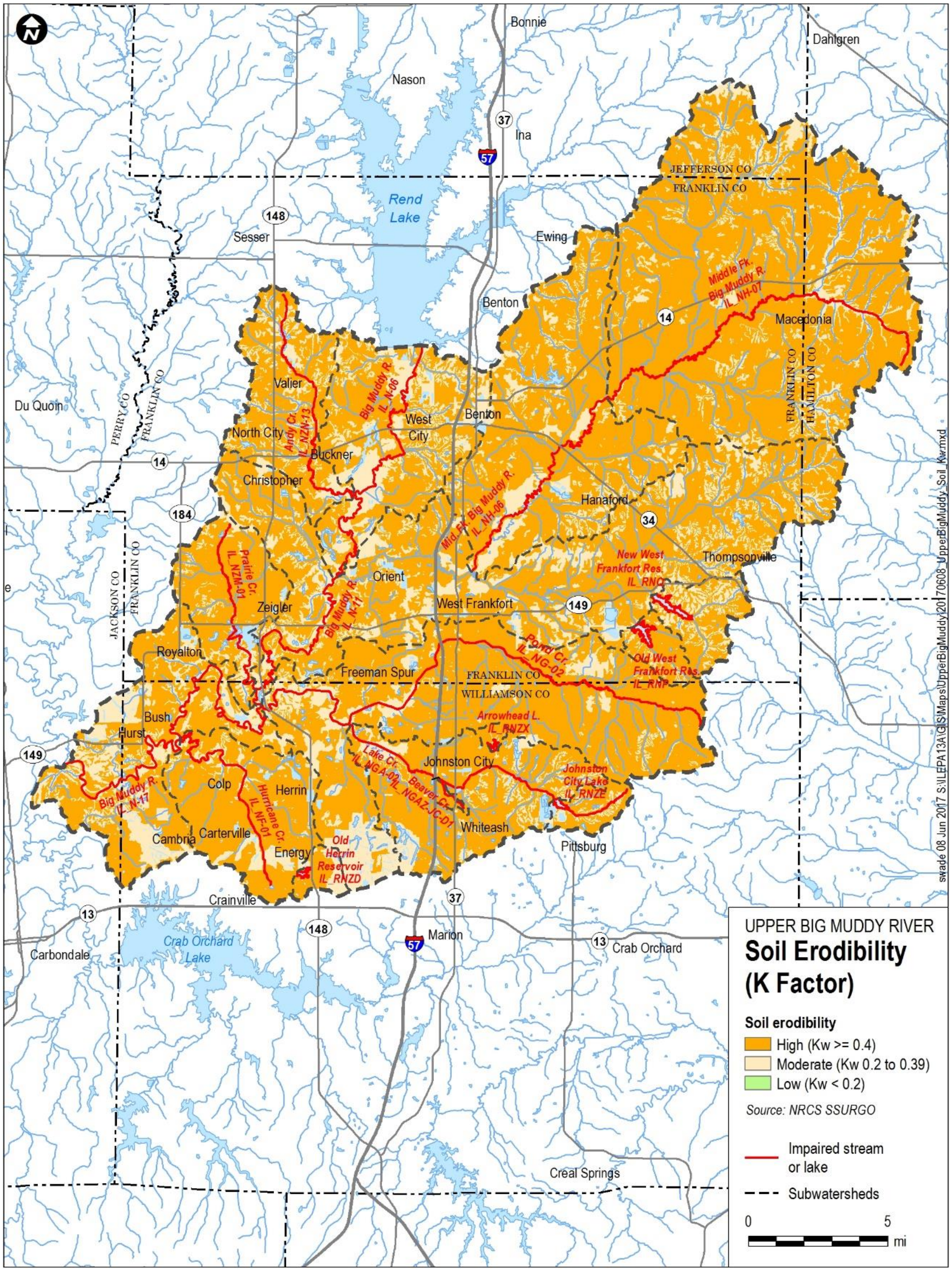


Figure 2-17. Soil Erodibility in the Upper Big Muddy River Watershed

2.2.5 Demographics and Urbanization

Population statistics and projections are available on a county basis. A majority of the watershed lies in Franklin and Williamson Counties, with smaller portions of the watershed in Jackson, Hamilton, and

Jefferson Counties. According to recent estimates from the United States Census Bureau, the population of Franklin County was 39,156, Williamson County was 67,560, Jackson County was 58,870, Jefferson County was 38,460, and Hamilton County was 8,061, as of July 1, 2016, which is the most recent data available[1]. The total 2016 population of these five counties equals 202,107, down from a total 5-county population of 213,851 in 2010. Population in Franklin, Jackson, Hamilton, and Jefferson counties decreased from 2010 to 2016. Williamson County saw an increase of 1.8% of population growth, but that was offset by the population losses from the other counties.

Urbanization in the watershed is centered in the towns of Herrin, West Frankfort, Benton, Johnston City, and Christopher (Table 2-2). The land cover data indicates that the watershed is approximately 7% urbanized, but very little of it is considered heavily developed. Any urban areas in this region are considered low intensity development.

Table 2-2. Estimated Watershed Population[2] of Towns in the Upper Big Muddy Watershed

NAME	Total Area (sq. mi)	Area In Watershed (sq. mi)	Percentage of Area in Watershed	Total Population	Estimated Watershed Population
Herrin	9.68	9.07	94%	12868	12067
West Frankfort	5.02	5.02	100%	7941	7941
Benton	5.66	4.77	84%	7148	6025
Johnston City	2.15	2.15	100%	3521	3521
Christopher	1.59	1.59	100%	2982	2982
Carterville	5.30	2.19	41%	5742	2375
Zeigler	1.37	1.37	100%	1771	1771
Cambria	1.41	1.23	87%	1337	1166
Energy	1.19	1.19	100%	1166	1166
Royalton	1.12	1.12	100%	1124	1124
West City	1.63	1.63	100%	789	789
North City	2.24	2.22	99%	755	749
Hurst	0.86	0.86	100%	705	705
Crainville	1.66	0.80	48%	1456	702
Thompsonville	2.05	2.01	98%	645	634
Valier	1.13	1.13	100%	601	601
Buckner	0.89	0.89	100%	467	467
Orient	0.75	0.75	100%	350	350
Whiteash	0.89	0.89	100%	328	328
Hanaford	1.01	1.01	100%	323	323
Freeman Spur	0.40	0.40	100%	254	254
Bush	0.46	0.46	100%	244	244
Colp	0.14	0.14	100%	219	219
Ewing	1.01	0.74	73%	294	216
Macedonia	0.27	0.27	100%	82	82

[1] https://www.census.gov/quickfacts/table/HCN010212/17075, accessed 12/21/17.
[2] Estimated 2000 populations obtained from Wikipedia on 5/31/17.

2.2.6 Land Cover

Using the 2011 Cropland Data Layer (CDL) for Illinois from the NRCS, it is apparent that the Upper Big Muddy River watershed is has significant agricultural land cover with approximately 34.2% of the watershed being cultivated crops and 24.2% being pasture and hay. Forest covers approximately 27% of the watershed and the remainder consists of developed open areas (Figure 2-18 and Table 2-3). Of the cultivated crops, nearly all of them are corn and soybeans. Corn accounts for 45% while soybeans account for 44%. Most of the remainder is a double crop of winter wheat/soybeans. Land cover is mapped in Figure 2-19.

Table 2-3. Upper Big Muddy River Watershed Land Cover

Classification	Acres
Cultivated crop	107,348
Developed, high intensity	383
Developed, low intensity	14,156
Developed, medium intensity	2,440
Developed, open	20,648
Forest	84,922
Grassland/pasture/hay	75,733
Water	4,604
Wetlands	3,088
Barren	112
Total	**313,435**

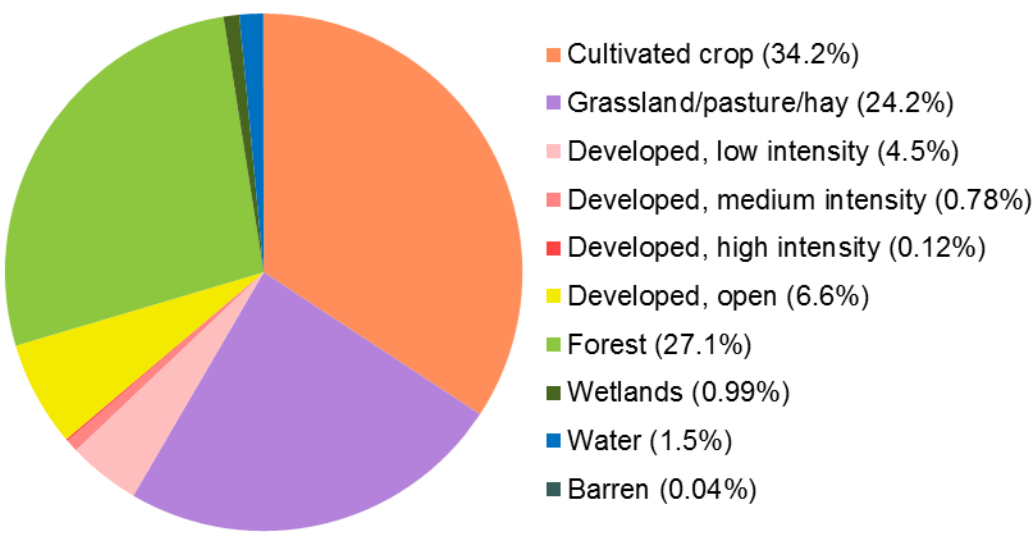


Figure 2-18. Upper Big Muddy River Watershed Land Cover Distribution

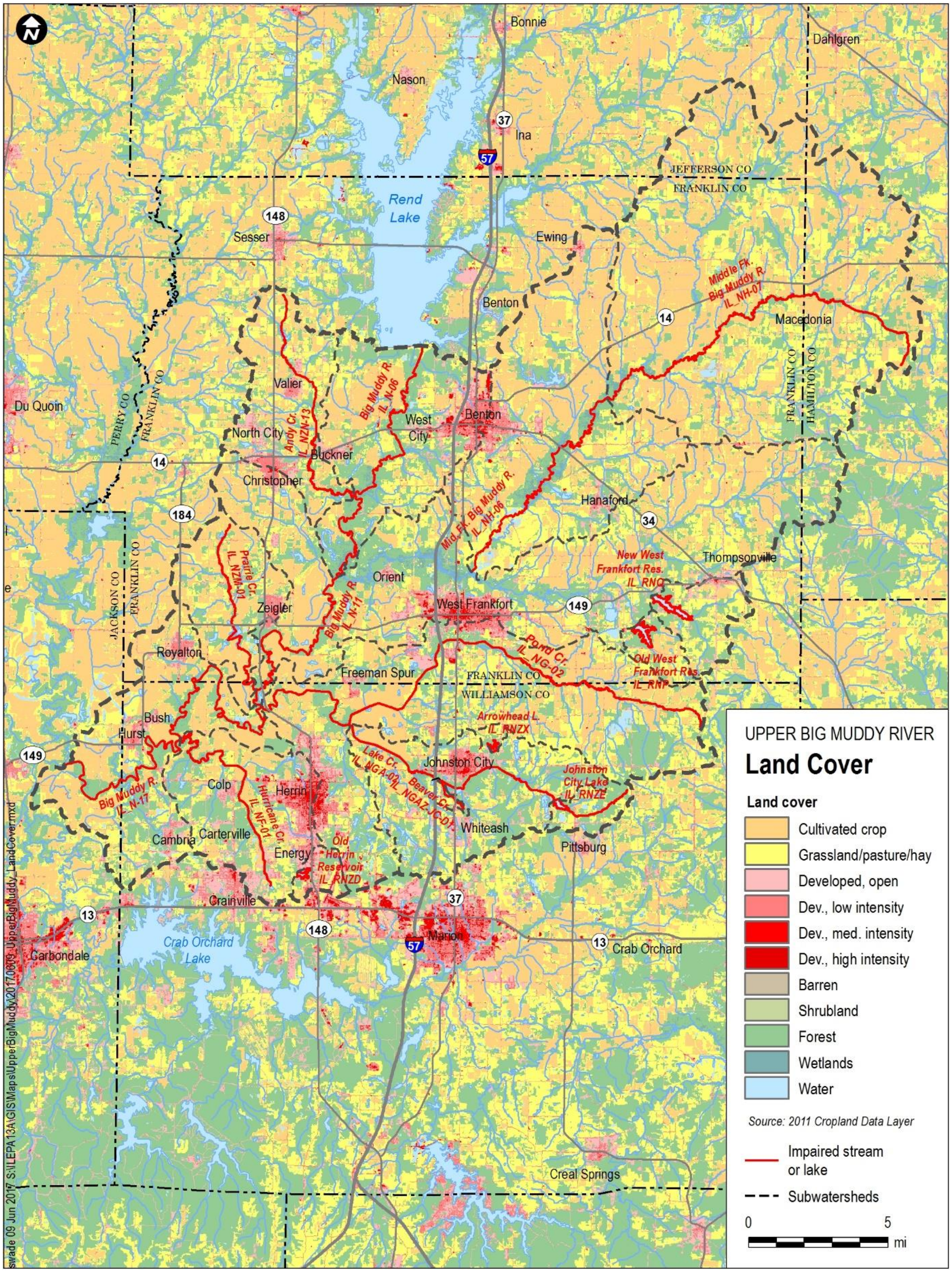


Figure 2-19. Land Cover in the Upper Big Muddy River Watershed

2.3 Additional Information Gathering

In addition to the desktop characterization described above, supplemental watershed inventory information was collected through a watershed tour and interviews with public officials. Additional information was obtained during the Stage 1 public meeting and public comment period. These activities are described below.

2.3.1 Watershed Tour

A tour of the Upper Big Muddy River watershed was conducted in 2013. This tour focused on the parts of the watershed containing impaired waters. The objectives of the watershed tour were:

- To verify observations made during the desktop analysis.
- To observe conditions at, and immediately upstream of, Illinois EPA water quality sampling locations.
- To identify concerns or potential causes of water quality impairment not previously identified

Most stream observations were made from bridge crossings or within a short hike of bridge crossings. A windshield survey of developed areas (towns) was conducted, but given the dominance of agriculture in the watershed, this contributed little information.

One significant observation made during the watershed tour was the prevalence of streambank erosion at all locations visited, including the lakes. Gully erosion was observed in the agricultural fields. Tile drains were observed as pipes protruding from streambanks, in some cases several feet above water level. The Upper Big Muddy River and its tributaries were generally mud-colored, which is logical based on the erodibility of the soils in the watershed, and the name of the river. In many cases, cropland was observed to extend to the edge of the streams.

2.3.2 Interviews with Local Officials

In addition to the extensive desktop watershed study and the watershed tour, the following local officials were contacted for information on a range of relevant subjects:

- Illinois EPA – source identification, mining, facility inspection reports, CAFOs, sampling, watershed groups.
- NRCS – ongoing implementation of watershed projects

These interviews did not reveal new information, but confirmed information previously developed, as well as the understanding of pollutant sources.

2.3.3 Public Input

A public meeting was conducted at the West Frankfort Public Library in West Frankfort, Illinois on Tuesday, December 17, 2013 a 3:30 PM, to present the findings of the watershed characterization and gather any additional information available from the public. The meeting was advertised, and public notices were mailed directly to the Soil and Water Conservation Districts, the Natural Resource Conservation Service, Illinois Farm Bureau and NPDES permittees in the watershed. A hard copy of the draft report was available for viewing prior to the meeting at the West Frankfort Public Library, Herrin City Hall, Christopher City Hall or Ewing Village Hall during business hours. The report was also available on-line at www.epa.state.il.us/public-notices. Approximately 25 people attended the meeting, in addition to the meeting organizers. A background presentation was made on the watershed characterization, covering the following topics:

- The TMDL process and water quality goals;
- Target water quality issues in the Upper Big Muddy River watershed; and
- Potential sources of pollutants.

Questions were invited and input was requested at the meeting. The public in attendance was in overall agreement with the findings of the watershed characterization.

3 Identification of Causes of Impairment and Pollutant Sources

As stated previously, this implementation plan was prepared to address excess phosphorus, fecal coliform, sediment, iron, and manganese in the several waterbodies throughout the Upper Big Muddy River watershed. This section addresses the likely pollutant sources within the subwatersheds contributing to the impaired water bodies. Pollutant sources were evaluated using the watershed characterization information presented in Section 2, available monitoring data, simple watershed modeling, GIS analysis of watershed characteristics, a site visit and calls to local agencies.

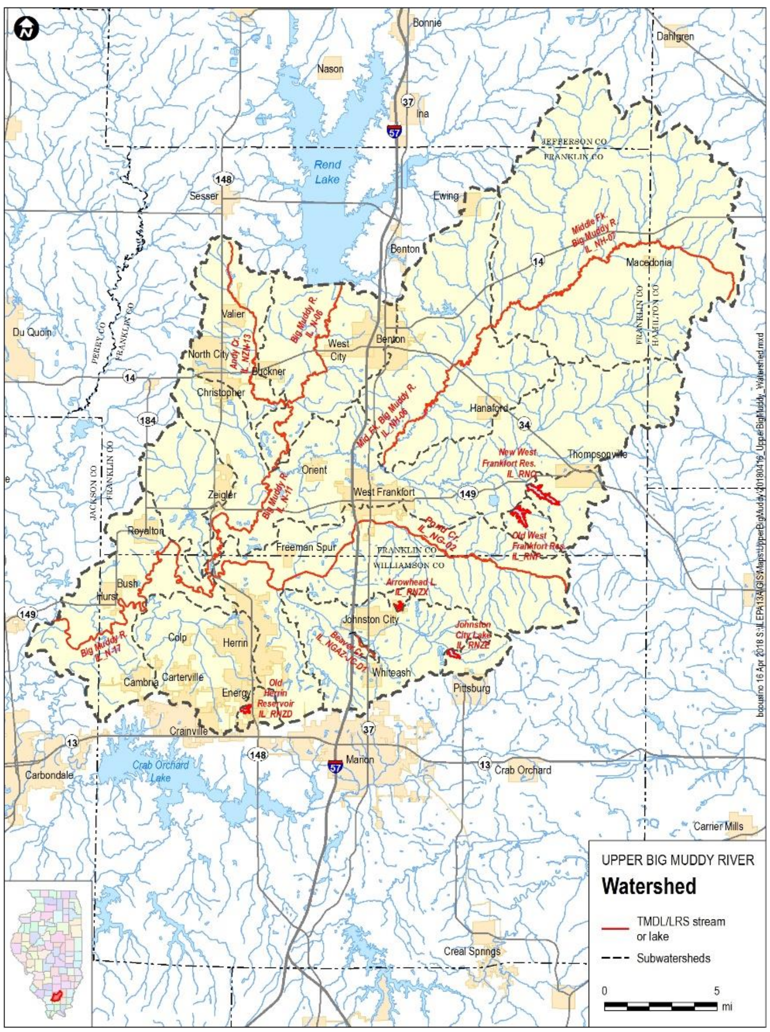


Figure 3-1. Study area map

3.1 Identification of Potential Pollutant Sources

The pollutants causing the waterbody impairments identified in the TMDLs and LRSs for the Upper Big Muddy River watershed include the following:

- Iron
- Manganese
- Sedimentation/Siltation
- Fecal Coliform
- Dissolved Oxygen
- Phosphorus (Total)

There are several potential sources of these pollutants loadings in predominantly agricultural watersheds, including:

- Agricultural runoff (iron, manganese, phosphorus, sediment, fecal coliform)
- Developed area runoff (iron, manganese, phosphorus, sediment, fecal coliform)
- Streambank erosion (phosphorus, sediment)
- Legacy phosphorus in lake sediments (phosphorus)
- Point sources (fecal coliform)

To estimate the existing loads from each of the sources, and their relative contributions to the impairments, watershed models were developed within Model My Watershed, which is a web-based application of the GWLF-E model. It includes separate models for estimating the surface runoff loads, as well as the streambank erosion loads. Each of the potential sources is evaluated below, with the watershed model results by impaired waterbody segment.

Pollutant loads from surface runoff and streambank erosion were calculated within Model My Watershed , which implements GWLF-E for runoff loads and estimates the watershed average lateral streambank erosion (LER) using an empirical method. This empirical method for streambank erosion is based on the average monthly flow, and a regression factor based on five key watershed parameters including animal density, curve number soil erodibility (k factor), mean watershed slope and percent of developed land in the watershed. This method was developed by Evans et al., 2003 based on sediment loading data from several watersheds within Pennsylvania. After a value for the LER has been computed, the total sediment load from streambank erosion within the watershed is calculated by multiplying the LER by the total length of streams in the watershed, the average streambank height, and the average soil bulk density. Within Model My Watershed, the default values for average streambank height of 1.5 m (4.92 ft) and 1500 kg/m^3 (93.6 lb /ft^3) are used for and soil bulk density, respectively. Runoff from cropland is calculated to contribute 48% of the total sediment load, and streambank erosion is calculated to contribute 51% of the total sediment loads. Runoff from the remaining land cover categories in the watershed contributes 1% or less of the total load each. Severe streambank erosion was observed in many locations (Figure 3-2).

Figure 3-2. Examples of streambank erosion in the Upper Big Muddy River watershed

3.2 Big Muddy River (IL_N-06)

This waterbody segment is impaired for sedimentation/siltation, with a LRS target of 26.2% reduction of TSS. This segment of the river is immediately downstream of the Rend Lake dam, so the hydrology has been significantly altered by the construction of the dam.

The Model My Watershed model results for the sediment loads in the HUC12 watershed that drain to this segment of the river was created are summarized in the figure below.

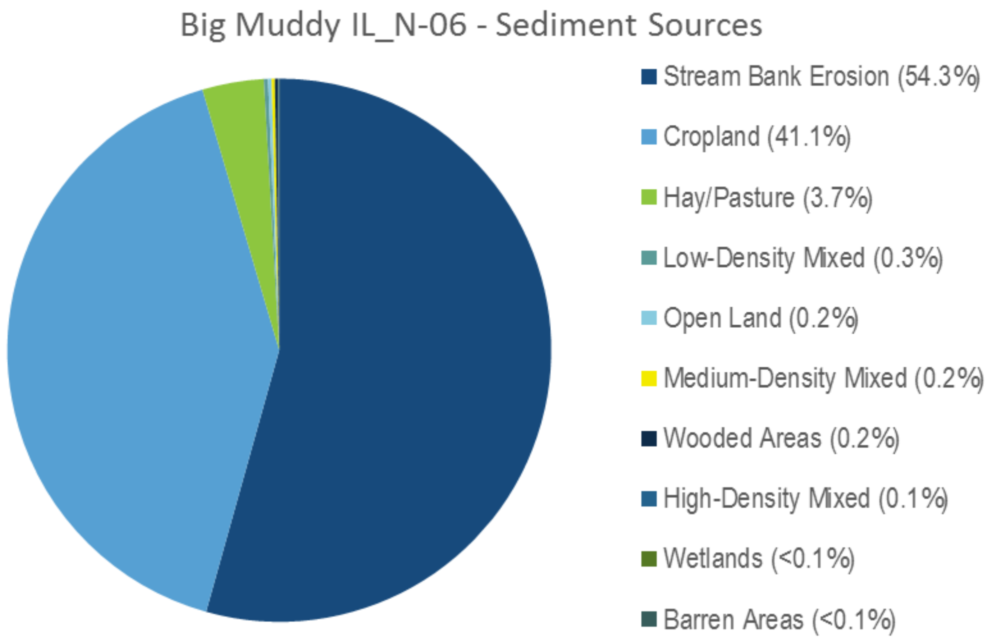


Figure 3-3. Big Muddy River IL_N-06 Sediment Sources

The model results indicate the stream bank erosion is the largest contributing source of sediment in this sub-watershed, followed by runoff from cropland and hay/pasture land cover. Management measures that focus on the reduction of those sources will be necessary to meet the LRS target reductions.

3.3 Big Muddy River (IL_N-11)

This waterbody segment is impaired for sedimentation/siltation, and for fecal coliform. The sediment/siltation impairment has a LRS target of 39.3% reduction of TSS. The fecal coliform has a TMDL that requires a 95.4% reduction in the load during wet weather flows. The analysis of the sources for sediment and siltation are analyzed separately below.

3.3.1 Sediment/Siltation

The Model My Watershed model results for the sediment loads in the HUC12 watershed that drain to this segment of the river was created and are summarized in the figure below.

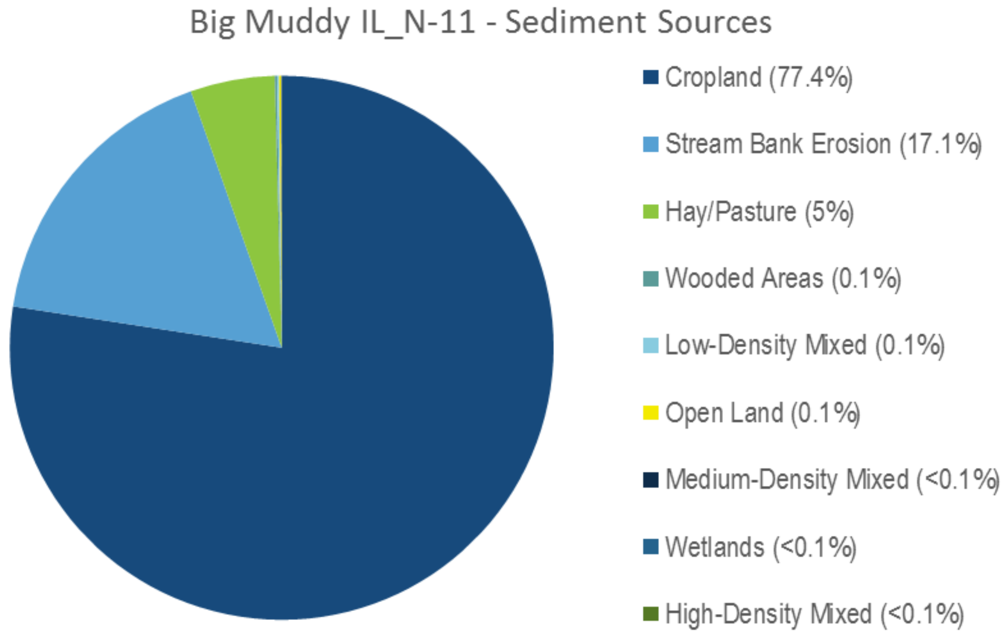


Figure 3-4. Big Muddy IL_N-11 Sediment Sources

The model results indicate the runoff from cropland and hay/pasture land cover are the largest contributing sources of sediment in this sub-watershed, followed by stream bank erosion. Management measures that focus on the reduction of those sources will be necessary to meet the LRS target reductions.

3.3.2 Fecal Coliform

Fecal coliform monitoring data collected in this segment of the Upper Big Muddy River at station IL_N-11 show a correlation between flow and fecal coliform concentrations. The majority of the water quality standard violations occur at higher flow conditions indicating fecal coliform is primarily being delivered to the river during wet weather conditions. Potential sources of fecal coliform during wet weather flow include nonpoint source runoff including runoff carrying waste from livestock, wildlife and pets. Sewage treatment plants and failing septic systems/surface discharging systems may also contribute, however, due to the low effluent flow of the sewage treatment plants in the watershed (<0.04 MGD), they are not identified as contributing significant fecal coliform loads to the creek. Septic systems and aeration units (wastewater is aerated, treated with chlorine and discharged to the surface) are used for sewage treatment in rural areas. Improperly functioning septic systems and aeration units would have a larger impact on the creek during dry weather conditions, but could also have an impact during wet weather conditions, if the septic system was not working properly or the surface discharge was not chlorinated. The contribution of these sources is not known, but a ballpark load was calculated, using literature values and assumptions regarding per capita flows (90 gal/person/day), 5% failure rate and homes served by septic systems (665). It is possible that failing onsite treatment systems could contribute 4% of the current bacteria load, and as such they are identified as a potential source that should be investigated further. This plan recommends coordination with the local health department to identify septic/aeration unit systems in need of improvement or repair.

Livestock can contribute fecal coliform loads via waste runoff, and if the animals are not fenced away from waterways, they may be a direct source to the streams. According to the most recent (2012) census of agriculture (NASS, 2017), cattle farms are the most common type of livestock farm within Jackson, Williamson, Hamilton, Jefferson, and Franklin Counties, but there are almost three times as many hogs as cattle suggesting hogs are more concentrated.

The potential fecal coliform load from livestock was calculated using available information. First, the number of animals in the Upper Big Muddy River watershed was approximated by scaling the countywide numbers of livestock and farms to the area of the watershed in each county. Fecal coliform loads were calculated for the three most common livestock, cattle and hogs, and turkeys, based on manure produced/animal and literature values describing the concentration of bacteria in manure (USEPA, 2001; http://www.agronext.iastate.edu/immag/pubs/smanure.pdf; and https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcs143_014211, https://engineering.purdue.edu/adt/PoultryManure/PoultryManureSurveyFinalReport.pdf).

This load is an estimate of what is produced. The load that reaches the stream is expected to be less due to bacterial decay, reductions from existing vegetative filters and other management practices to capture or treat bacteria, and other factors. However, this calculation showed that livestock could potentially contribute up to 50% of the current fecal coliform load, although the true contribution is uncertain.

Table 3-1. Livestock and Poultry Census Data (2012) and Estimated Fecal Coliform Loads

Census Item	Est. # of Farms	# of Animals	**Fecal coliform/yr**
Cattle, including calves - inventory	7	246	6.3E+15
Hogs and pigs – inventory	1	653	2.5E+14
Turkeys	1	3,187	3.4E+14

Fecal coliform loads in runoff may also originate from wildlife although their contribution is unknown. Management measures that slow and filter runoff will help reduce loads from these sources.

3.4 Big Muddy River (IL_N-17)

This waterbody segment is impaired for sedimentation/siltation, with a LRS target of 70.8% reduction of TSS. The Model My Watershed model results for the sediment loads in the HUC12 watershed that drain to this segment of the river was created are summarized in the figure below.

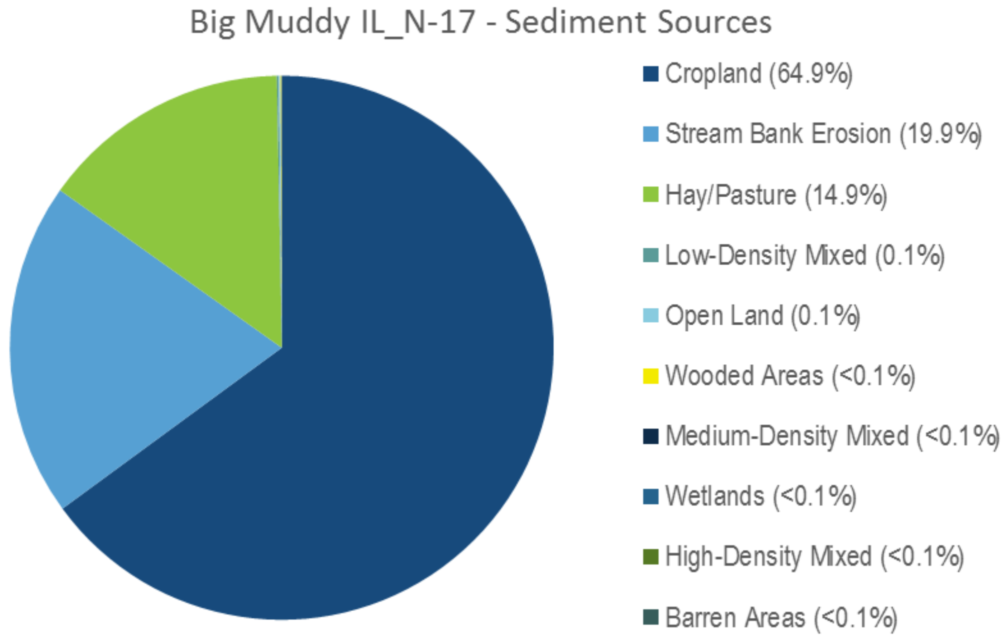


Figure 3-5. Big Muddy IL_N-17 Sediment Sources

The model results indicate the runoff from cropland and hay/pasture land cover are the largest contributing sources of sediment in this sub-watershed, followed by stream bank erosion. Management measures that focus on the reduction of those sources will be necessary to meet the LRS target reductions.

3.5 Pond Creek (IL_NG-02)

This waterbody segment is impaired for sedimentation/siltation, with a LRS target of 62.7% reduction of TSS. The Model My Watershed model results for the sediment loads in the HUC12 watershed that drain to this segment of the river was created are summarized in the figure below.

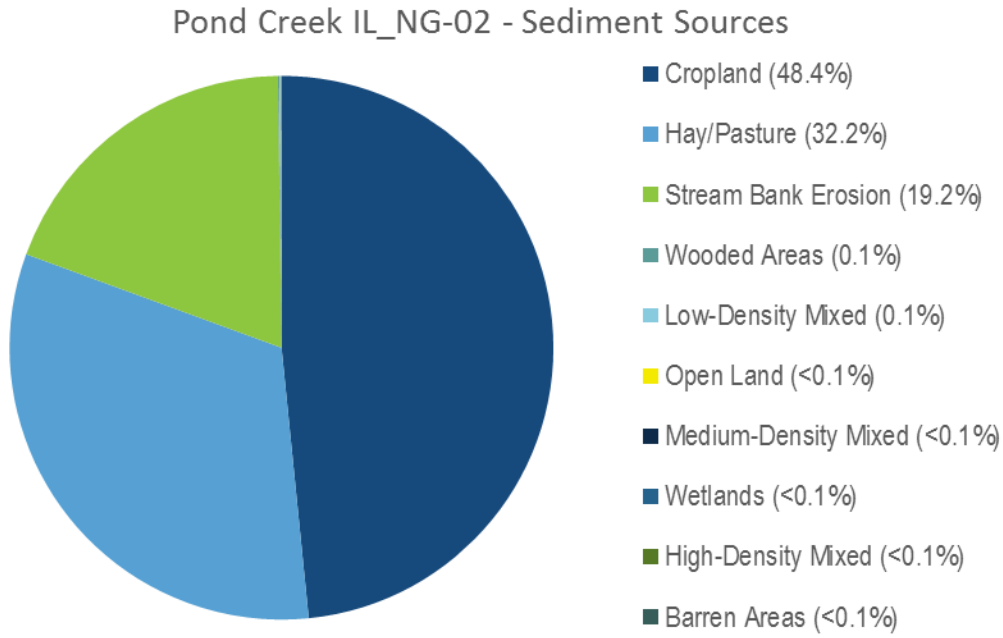


Figure 3-6. Pond Creek IL_NG-02 Sediment Sources

The model results indicate the runoff from cropland and hay/pasture land cover are the largest contributing sources of sediment in this sub-watershed, followed by stream bank erosion. Management measures that focus on the reduction of those sources will be necessary to meet the LRS target reductions.

3.6 Middle Fork Big Muddy River (IL_NH-07)

This waterbody segment is impaired for sedimentation/siltation, with a LRS target of 55.5% reduction of TSS. The Model My Watershed model results for the sediment loads in the subwatershed that drains to this segment of the river was created are summarized in the figure below.

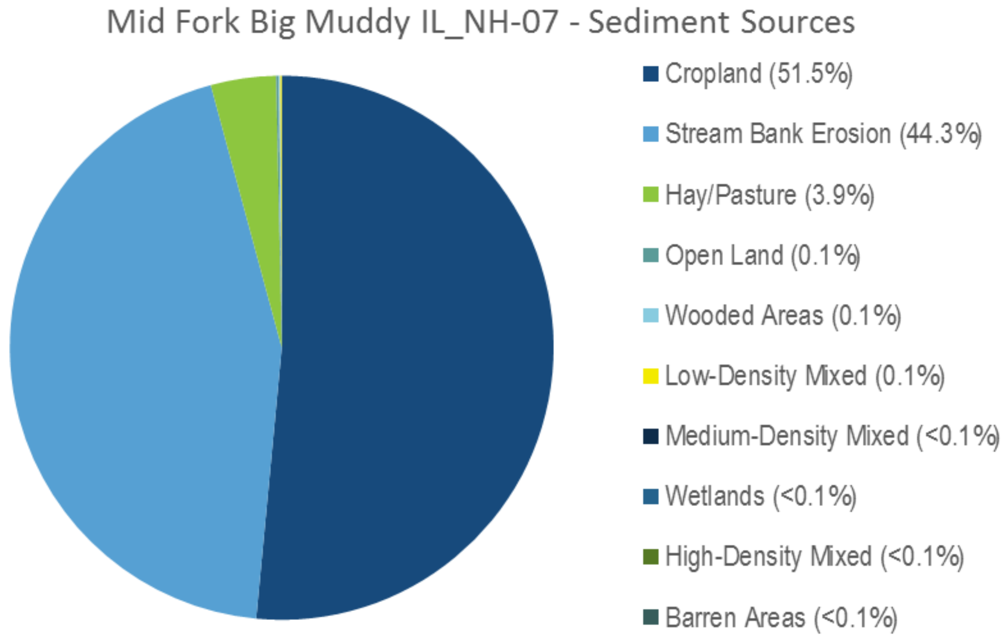


Figure 3-7. Middle Fork Big Muddy IL_NH-07 Sediment Sources

The model results indicate the runoff from cropland and hay/pasture land cover are the largest contributing sources of sediment in this sub-watershed, followed by stream bank erosion. Management measures that focus on the reduction of those sources will be necessary to meet the LRS target reductions.

3.7 Beaver Creek (IL_NGAZ-JC-D1)

There was only one water quality sample analyzed for manganese in Beaver Creek, and it exceeded the water quality standard. The sample was taken during a flow at the lower end of the normally encountered flows (30% to 70%), indicating that there are dry weather sources that could be contributing to this impairment. Since there is only one sample, there is no information on whether this impairment is further impacted by wet weather sources.

In the Soil Survey of Williamson County, Illinois, the description of the soil profiles for all of the soils in the Beaver Creek subwatershed are noted as having rounded masses of iron and manganese in the top horizons of the soil profile. The most likely source of the manganese in the stream is from agricultural and developed area runoff during wet weather events carrying eroded soils that contain manganese. Management measures focused on reducing soil erosion will be the most effective way to reduce the manganese in the stream.

The Model My Watershed model results for the sediment loads in the Beaver Creek watershed are summarized in the figure below.

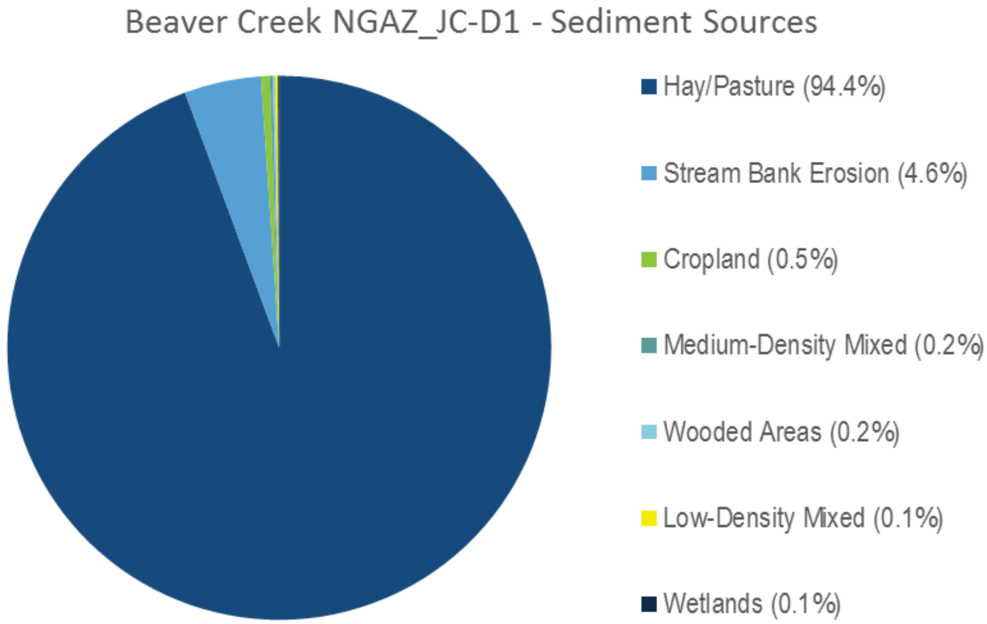


Figure 3-8. Beaver Creek NGAZ_JC-D1 Sediment Sources

The model results indicate the runoff from hay/pasture land cover is the largest contributing sources of sediment in this sub-watershed, followed by stream bank erosion.

3.8 Andy Creek (IL_NZN-13)

This stream segment is listed as being impaired by excess dissolved iron loads. The load duration curve for Andy Creek indicates that iron loads exceed the allowable loads during the higher flow levels, indicating that wet weather sources or runoff contribute to the observed violation of the water quality standard. In the Soil Survey of Franklin County, Illinois, the description of the soil profiles for over 90% of the soils in the Andy Creek subwatershed are noted as having rounded masses of iron and manganese in the top horizons of the soil profile. The most likely source of the iron in the stream is from agricultural and developed area runoff during wet weather events.

The Model My Watershed model results for the sediment loads in the Beaver Creek are summarized in the figure below.

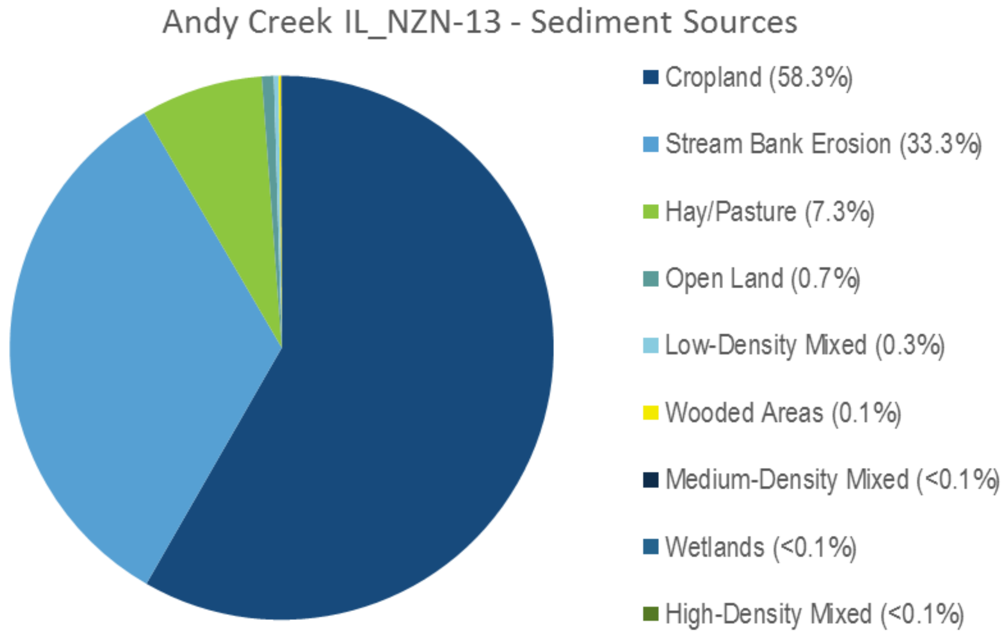


Figure 3-9. Andy Creek IL_NZN-13 Sediment Sources

The model results indicate the runoff from cropland and hay/pasture land cover is the largest contributing sources of sediment in this sub-watershed, followed by stream bank erosion. Reducing the sources of sediment supply to the stream will help to reduce the iron concentrations due to the high iron content in the soils.

3.9 Middle Fork Big Muddy River (IL_NH-06)

Fecal coliform monitoring data collected in the Middle Fork Big Muddy River at station IL_NH-06 show a correlation between flow and fecal coliform concentrations. The majority of the water quality standard violations occur at higher flow conditions indicating fecal coliform is primarily being delivered to the river during wet weather conditions. Potential sources of fecal coliform during wet weather flow include nonpoint source runoff including runoff carrying waste from livestock, wildlife and pets. Sewage treatment plants and failing septic systems/surface discharging systems may also contribute, however, due to the low effluent flow of the sewage treatment plants in the watershed (<0.04 MGD), they are not identified as contributing significant fecal coliform loads to the creek. Septic systems and aeration units (wastewater is aerated, treated with chlorine and discharged to the surface) are used for sewage treatment in rural areas. Improperly functioning septic systems and aeration units would have a larger impact on the creek during dry weather conditions, but could also have an impact during wet weather conditions, if the septic system was not working properly or the surface discharge was not chlorinated. The contribution of these sources is not known, but a ballpark load was calculated, using literature values and assumptions regarding per capita flows (90 gal/person/day), 5% failure rate and homes served by septic (665). It is possible that failing onsite systems could contribute 4% of the current bacteria load, and as such they are identified as a potential source that should be investigated further. This plan recommends coordination with the local health department to identify systems in need of improvement or repair.

Livestock can contribute fecal coliform loads via waste runoff, and if the animals are not fenced away from waterways, they may be a direct source to the streams. According to the most recent (2012) census of agriculture (NASS, 2017), cattle farms are the most common type of livestock farm within Jackson, Williamson, Hamilton, Jefferson, and Franklin Counties, but there are almost three times as many hogs as cattle suggesting hogs are more concentrated.

The potential fecal coliform load from livestock was calculated using available information. First, the number of animals in the Upper Big Muddy River watershed was approximated by scaling the countywide numbers of livestock and farms to the area of the watershed in each county. Fecal coliform loads were calculated for the three most common livestock, cattle and hogs, and turkeys, based on manure produced/animal and literature values describing the concentration of bacteria in manure (USEPA, 2001; http://www.agronext.iastate.edu/immag/pubs/smanure.pdf; and https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcs143_014211, https://engineering.purdue.edu/adt/PoultryManure/PoultryManureSurveyFinalReport.pdf).

This load is an estimate of what is produced. The load that reaches the stream is expected to be less due to bacterial decay, reductions from existing vegetative filters and other management practices to capture or treat bacteria, and other factors. However, this calculation showed that livestock could potentially contribute up to 50% of the current fecal coliform load, although the true contribution is uncertain.

Table 3-2. Livestock and Poultry Census Data (2012) and Estimated Fecal Coliform Loads

Census Item	Est. # of Farms	# of Animals	**Fecal coliform/yr**
Cattle, including calves – inventory	19	654	1.7E+16
Hogs and pigs – inventory	3	1,733	6.5E+14
Turkeys – inventory	1	8,461	9.1E+14

Fecal coliform loads in runoff may also originate from wildlife although their contribution is unknown. Management measures that slow and filter runoff will help reduce loads from these sources.

3.10 Herrin Old Reservoir (IL_RNZD)

In preparing the TMDL for the Herrin Old Reservoir, it was determined that the primary source of the elevated phosphorus concentrations contributing to the impairment was from the internal loading from phosphorus released from organic sediments that have accumulated in the reservoir. The sampling data indicated that the only exceedances of the water quality standard were at the deepest parts of the lake, which indicates phosphorus is entering the water column from legacy phosphorus in the lake bottom sediments, and that internal phosphorus source needs to be reduced. The internal phosphorus flux could be reduced using by either capping the sediments (e.g. alum treatment or similar), management actions to remove organic sediments from the lake (dredging), as well as a long-term decrease in the future in response to external phosphorus load reductions.

Historical phosphorus loads to the lakes may accumulate in bottom sediments, and the resulting unusually high sediment phosphorus can subsequently be introduced into water over time. These areas are known as legacy sediment sources. In-lake phosphorus data collected at various depths indicates Legacy phosphorus loads from the sediments could be confirmed with sediment sampling and remediation could be pursued by dredging out the sediments.

3.11 Johnston City Reservoir (IL_RNZE)

In preparing the TMDL for the Johnston City Reservoir, it was determined that the primary source of the elevated phosphorus concentrations contributing to the impairment was from the internal loading from phosphorus released from organic sediments that have accumulated in the reservoir. The sampling data indicated that the only exceedances of the water quality standard were at the deepest parts of the lake, which indicates phosphorus is entering the water column from legacy phosphorus in the lake bottom sediments, and that internal phosphorus source needs to be reduced. The internal phosphorus flux could be reduced using by either capping the sediments (e.g. alum treatment or similar), management actions to remove organic sediments from the lake (dredging), as well as a long-term decrease in the future in response to external phosphorus load reductions.

3.12 Arrowhead Reservoir (Williamson) (IL_RNZX)

The TMDL loading capacity calculated for the Arrowhead (Williamson) Reservoir shows that the phosphorus loadings to this lake require a 30% reduction from existing tributary loads as well as eliminating the internal phosphorus loading from organic sediments that have accumulated in the reservoir. The internal phosphorus flux could be reduced using by either capping the sediments (e.g. alum treatment or similar), management actions to remove organic sediments from the lake (dredging), as well as a long-term decrease in the future in response to external phosphorus load reductions.

The Model My Watershed model results for the watershed phosphorus loads in the contributing watershed are summarized in the figure below.

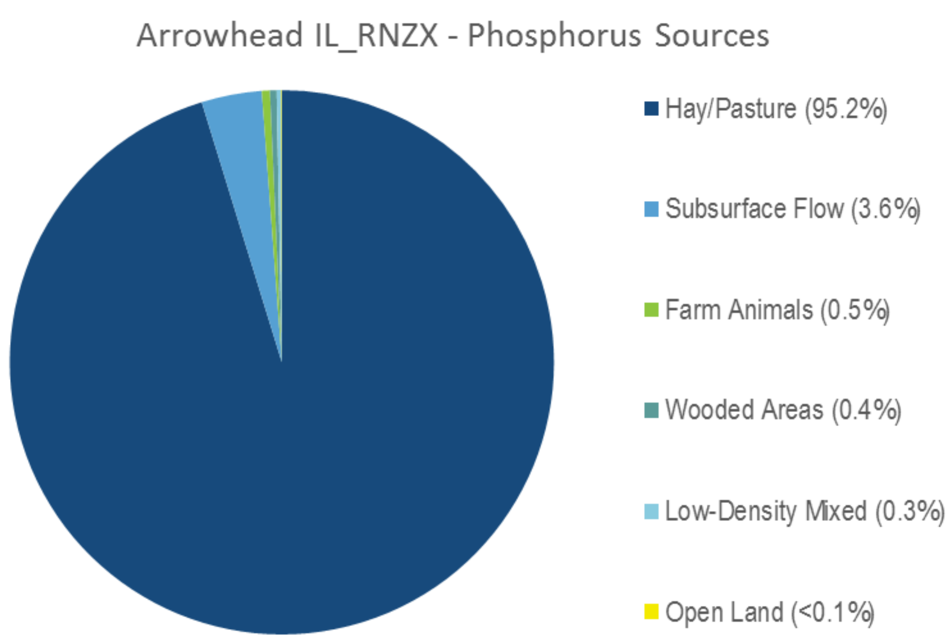


Figure 3-10. Arrowhead IL_RNZX Phosphorus Sources

The model results indicate the runoff from hay/pasture land cover is the largest contributing sources of phosphorus in this sub-watershed. The land cover within the watershed indicates that that pasture/hay covers approximately 48.8% of the watershed. Management actions within this watershed should focus on that land use to reduce the watershed phosphorus loads.

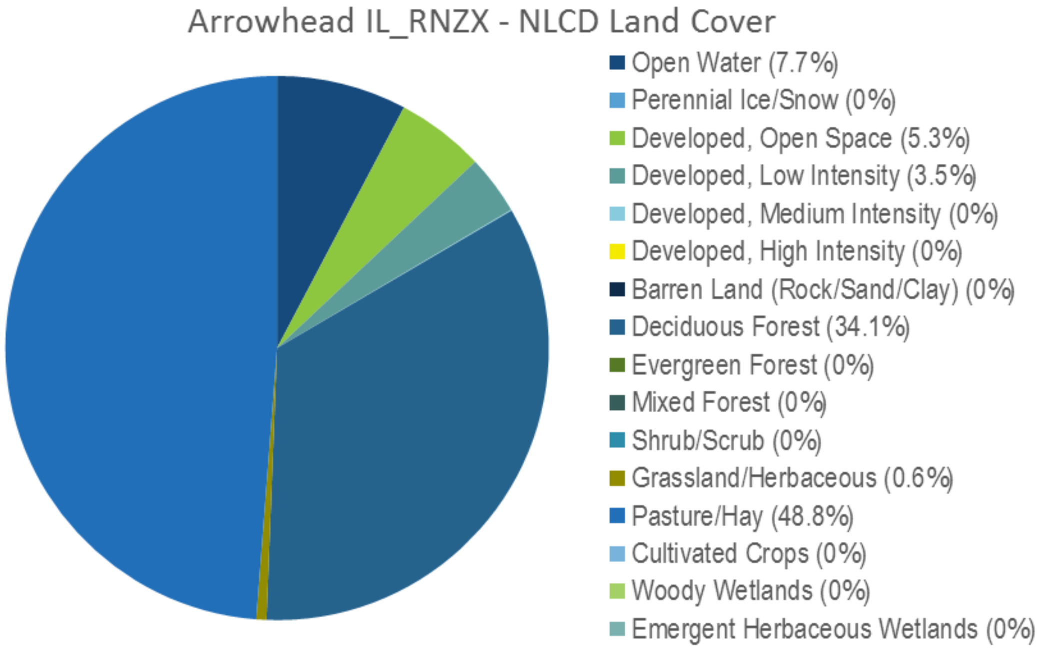


Figure 3-11. Arrowhead IL_RNZX Land Cover

3.13 West Frankfort Old Reservoir (IL_RNP)

The TMDL loading capacity calculated for the West Frankfort Old Reservoir shows that the phosphorus loadings to this lake require a 75% reduction from existing tributary loads, as well as eliminating the internal phosphorus loading from organic sediments that have accumulated in the reservoir. The internal phosphorus flux could be reduced using by either capping the sediments (e.g. alum treatment or similar), management actions to remove organic sediments from the lake, as well as a long-term decrease in the future in response to external phosphorus load reductions.

The Model My Watershed model results for the watershed phosphorus loads in the contributing watershed are summarized in the figure below.

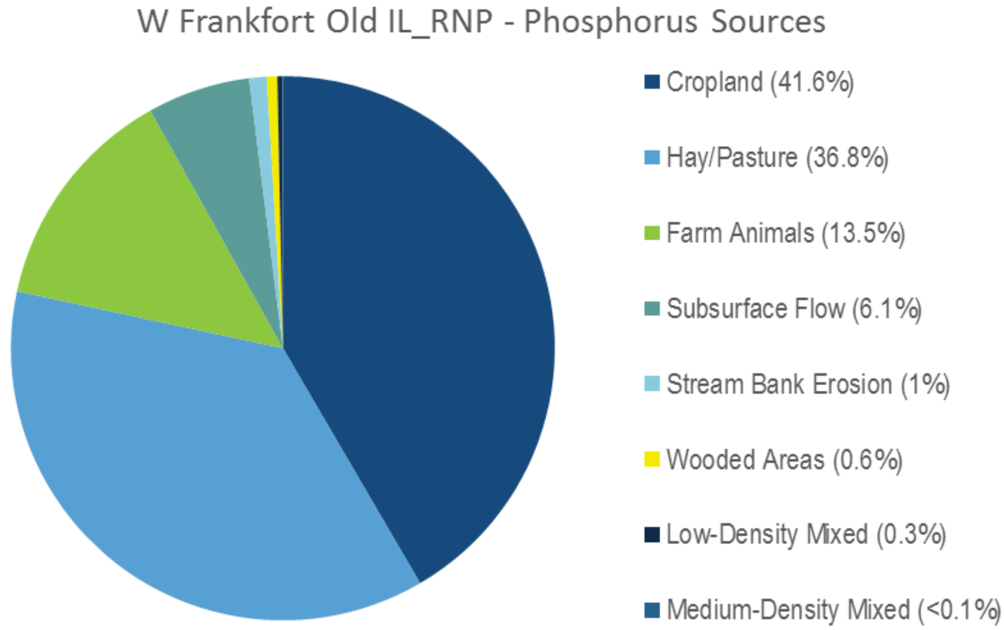


Figure 3-12. W. Frankfort Old IL_RNP Phosphorus Sources

The model results indicate the runoff from cropland and hay/pasture land cover is the largest contributing sources of phosphorus in this sub-watershed, followed by sources from farm animals. The land cover within the watershed indicates that that pasture/hay covers approximately 42.1% of the watershed, and cropland covers 12.8%. Management actions within this watershed should focus on those land uses to reduce the watershed phosphorus loads, as well as actions related to nutrient reductions in animal waste.

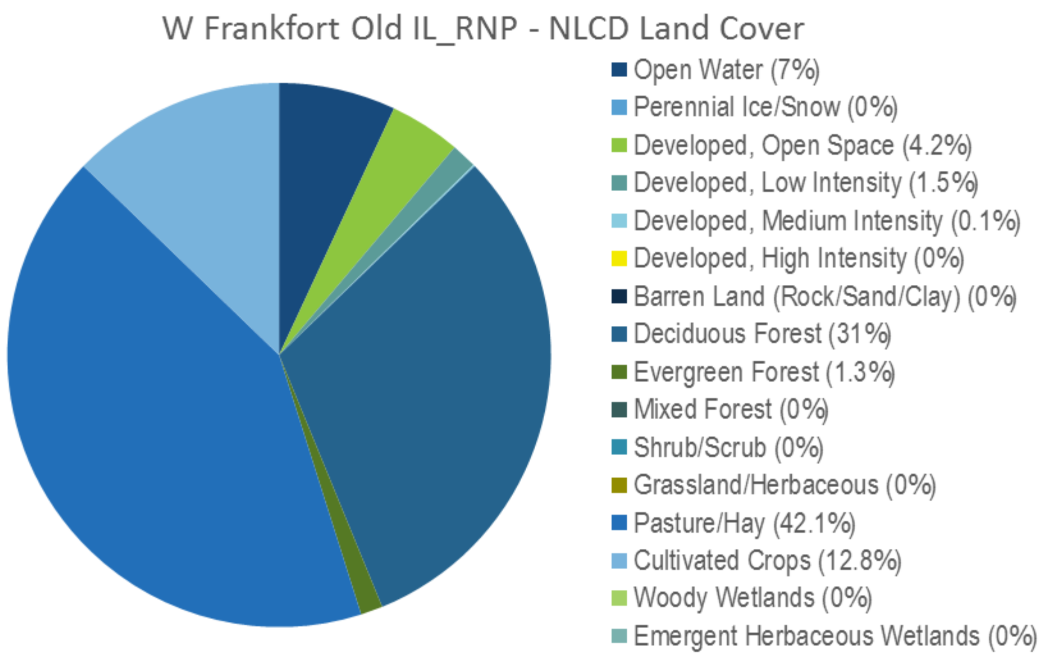


Figure 3-13. W. Frankfort Old IL_RNP Land Cover

3.14 West Frankfort New Reservoir (IL_RNQ)

The TMDL loading capacity calculated for the West Frankfort Old Reservoir shows that the phosphorus loadings to this lake require a 75% reduction from existing tributary loads, as well as eliminating the internal phosphorus loading from organic sediments that have accumulated in the reservoir, and implanting waste load reductions at the Thompsonville STP. The internal phosphorus flux could be reduced using by either capping the sediments (e.g. alum treatment or similar), management actions to remove organic sediments from the lake, as well as a long-term decrease in the future in response to external phosphorus load reductions.

The Model My Watershed model results for the watershed phosphorus loads (excluding the Thompsonville STP) in the contributing watershed are summarized in the figure below.

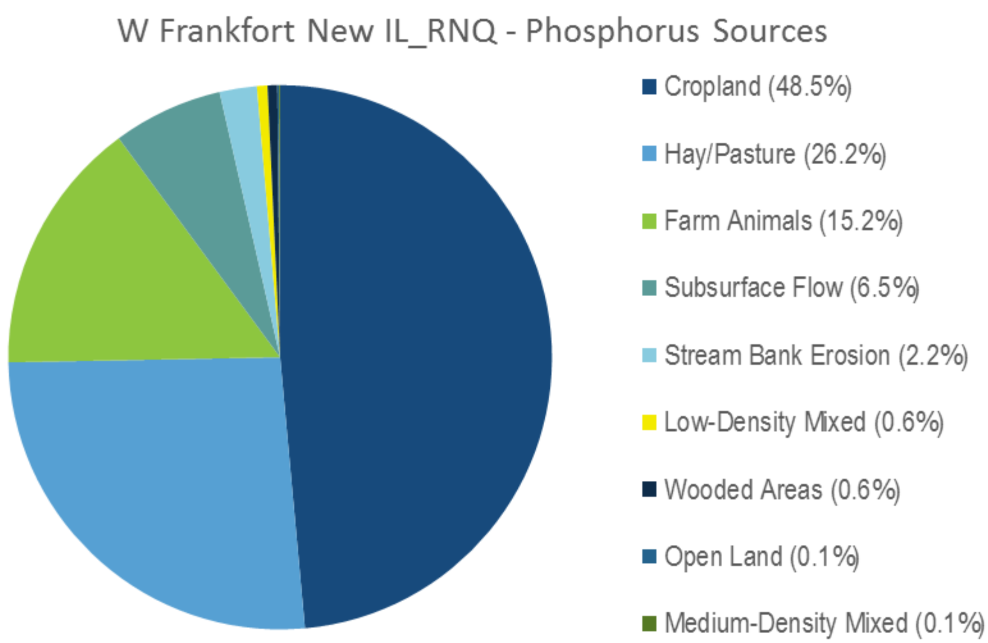
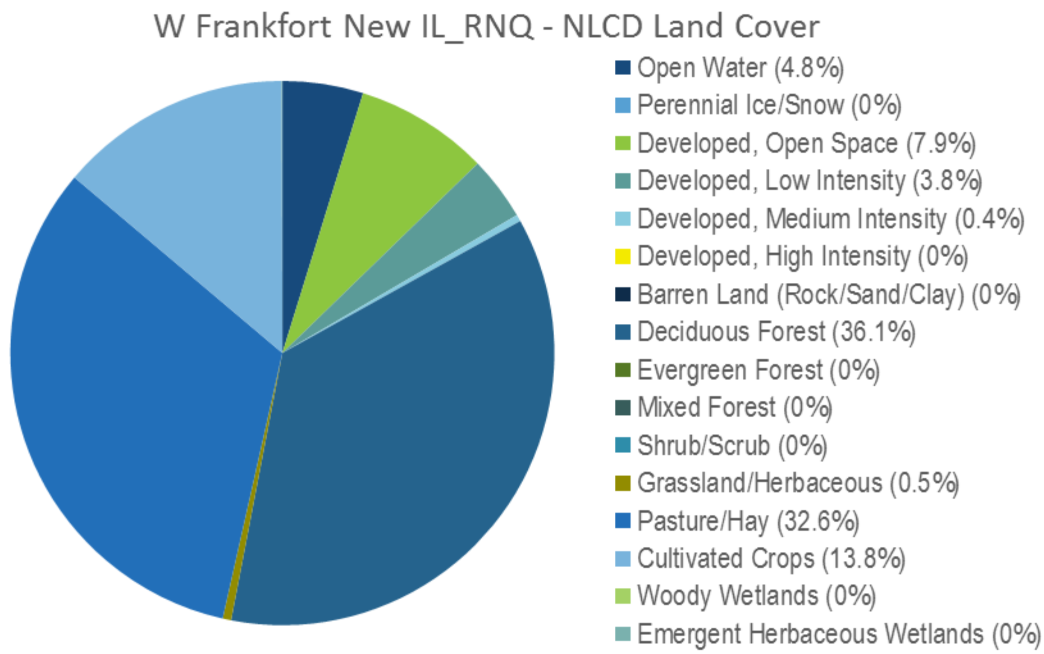


Figure 3-14. W. Frankfort New IL_RNQ Phosphorus Sources

The model results indicate the runoff from cropland and hay/pasture land cover is the largest contributing sources of phosphorus in this sub-watershed, followed by sources from farm animals. The land cover within the watershed indicates that that pasture/hay covers approximately 42.1% of the watershed, and cropland covers 12.8%. Management actions within this watershed should focus on those land uses to reduce the watershed phosphorus loads, as well as actions related to nutrient reductions in animal waste.



3.15 Summary of Priority Sources of Pollutants

Based on the watershed characterization and evaluation of potential sources of pollutants in the drainage areas of the impaired waterbodies in the Upper Big Muddy River watershed, the following conclusions regarding priority sources of are supported:

- Runoff is the primary pathway for phosphorus, sediment, iron, manganese, and fecal coliform loading to the impaired waterbodies, with streambank erosion also contributing to sediment loading.
- Runoff from agricultural lands with livestock is a significant contributor of fecal coliform bacteria. Failing septic systems or surface discharging systems may also be contributing a smaller portion of the bacteria load. Other sources such as wildlife may also be contributing, but their contribution is unknown.

The controls described in subsequent sections of this implementation plan are focused on reducing the pollutants associated with the waterbody impairments from these sources.

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4 Recommended Management Measures

Load reduction targets and recommended non-point source control measures to reduce pollutant loading in the Upper Big Muddy River watershed are discussed in this section.

4.1 TMDL and Load Reduction Targets

4.1.1 Sediment LRS Targets

The Upper Big Muddy River Watershed TMDL Stage 3 Report (LimnoTech, 2017) presents the TSS LRS for the stream segments impaired by sedimentation/siltation (TSS). The target TSS reductions are presented in Table 4-1. For purposes of this implementation plan, a watershed model was developed to calculate the current TSS load contribution from different sources. These results were used in conjunction with percent reductions to determine the actual loads that can be reduced by controls targeted at different sources. Table 4-1 presents the current average annual TSS load, the percent load reduction needed and the load of TSS to be reduced to meet the LRS target.

Table 4-1. TSS Reduction Target

Stream (Segment)	Current Average TSS Load (lbs./yr.)	Target Percent Reduction	Target Average Annual TSS Load to be Reduced (lbs./yr.)
Big Muddy R. (IL_N-06)	12,173,346	26.2%	3,189,417
Big Muddy R. (IL_N-11)	9,577,780	39.3%	3,764,068
Big Muddy R. (IL_N-17)	16,541,907	70.8%	11,711,670
Pond Cr. (IL_NG-02)	20,746,432	62.7%	13,008,013
M. Fk. Big Muddy (IL_NH-07)	44,360,594	55.5%	24,620,130

The load contribution by source was calculated using watershed modeling, and the model-based TSS loads by source are shown above in Section 3. In general, the dominant TSS sources are runoff from cropland and hay/pasture land cover, and streambank erosion.

4.1.1 Iron TMDL Target

The Upper Big Muddy River Watershed TMDL Stage 3 Report (LimnoTech, 2017) presents the TMDL for iron for Andy Creek (IL_NZN-13). Because the iron loads to the stream are most likely related to soil erosion and runoff due to the iron content of the soils in the watershed, a watershed model was developed to calculate the current sediment load contributions from different sources. Management measures to control the sediment loads will help to reduce the iron loads accordingly. These results were used in conjunction with the iron TMDL reductions to determine the actual loads that can be reduced by controls targeted at different sources. Table 4-2 presents the current average annual sediment load, the percent load reduction needed to meet the iron load reduction in the TMDL, and the load of sediment to be reduced to meet the iron TMDL reduction.

Table 4-2. Andy Creek (IL_NZN-13) Sediment Reduction Target to meet Iron TMDL

Stream (Segment)	Current Average TSS Load (lbs./yr.)	Target Percent Reduction	Target Average Annual TSS Load to be Reduced (lbs./yr.)
Andy Creek (IL_NZN-13)	8,082,330	9.9%	800,151

The load contribution by source was calculated using watershed modeling, and the model-based TSS loads by source are shown above in Section 3. Sediment loads are primarily runoff from cropland and streambank erosion.

4.1.1 Manganese TMDL Target

The Upper Big Muddy River Watershed TMDL Stage 3 Report (LimnoTech, 2017) presents the TMDL for manganese for Beaver Creek (NGAZ_JC-D1). Because the manganese loads to the stream are most likely related to soil erosion and runoff due to the manganese content of the soils in the watershed, a watershed model was developed to calculate the current sediment load contributions from different sources. Management measures to control the sediment loads will help to reduce the manganese loads accordingly. These results were used in conjunction with the manganese TMDL reductions to determine the actual loads that can be reduced by controls targeted at different sources. Table 4-3 presents the current average annual sediment load, the percent load reduction needed to meet the manganese load reduction in the TMDL, and the load of sediment to be reduced to meet the manganese TMDL reduction.

Table 4-3. Beaver Creek (NGAZ_JC-D1) Sediment Reduction Target to meet Manganese TMDL

Stream (Segment)	Current Average TSS Load (lbs./yr.)	Target Percent Reduction	Target Average Annual TSS Load to be Reduced (lbs./yr.)
Beaver Creek (NGAZ_JC-D1)	155,867 lbs./yr.	24.4%	38,032

The load contribution by source was calculated using watershed modeling, and the model-based TSS loads by source are shown above in Section 3. TSS loads are primarily from runoff from hay/pasture land cover.

4.1.2 Phosphorus TMDL Target

The Upper Big Muddy River Watershed TMDL Stage 3 Report (LimnoTech, 2017) presents the total phosphorus LRS and total phosphorus TMDL for Herrin Old (IL_RNZD), Johnston City (IL_RNZE), Arrowhead (Williamson) (IL_RNZX), West Frankfort Old (IL_RNP), and West Frankfort New (IL_RNQ) reservoirs, respectively. The percent reduction in phosphorus load is presented in Table 4-4. For purposes of this implementation plan, a watershed model was developed to calculate current phosphorus loads from different land uses (USEPA, 2000), as well as livestock. These results were used in conjunction with percent reductions to determine the actual loads that can be reduced by controls targeted at different sources. Table 4-4 presents the current average annual phosphorus load for each lake, the percent load reduction needed and the targeted load of total phosphorus to be reduced in each subwatershed.

Table 4-4. Total Phosphorus Reduction Targets to meet TMDLs

Lake (ID)	Current Average Annual Watershed Phosphorus Load (lbs./yr.)	Target Percent Reduction	Target Average Annual Phosphorus Load to be Reduced (lbs./yr.)
Herrin Old (IL_RNZD)	186	0.0%	0
Johnston City (IL_RNZE)	387	0.0%	0
Arrowhead (Williamson) (IL_RNZX)	87.5	30.0%	26.25
West Frankfort Old (IL_RNP)	1,599	75.0%	1,199
West Frankfort New (IL_RNQ)	1,998	75.0%	1,499

The source contributions from the watersheds are noted in Section 3 above, and are primarily runoff from cropland and hay/pasture land cover.

All of the lakes noted in the table above have historical phosphorus loads that have accumulated in the bottom sediments, and the resulting unusually high sediment phosphorus can subsequently be introduced into water over time, particularly during summer months with low dissolved oxygen at the bottom of the reservoir. These areas are known as legacy sediment sources. In-lake phosphorus data collected at various depths indicates phosphorus is entering the water column from legacy phosphorus in the lake bottom sediments. Legacy phosphorus loads from the sediments could be confirmed with sediment sampling and remediation could be pursued by dredging out the sediments, or capping the sediments (e.g. alum treatment). Those management measures will need to be pursued in addition to the reductions in watershed loads noted in the table able.

4.1.3 Fecal coliform

The Upper Big Muddy River Watershed TMDL Stage 3 Report (LimnoTech, 2017) presents the fecal coliform TMDLs for two stream segments within the Upper Big Muddy River watershed. Reductions are needed over a range of flow conditions; however, the largest reductions are needed during the highest flow conditions.

Table 4-5 presents the current fecal coliform load for the Upper Big Muddy River (IL_N-11) and the Middle Fork Big Muddy River (IL_NH-06), the percent load reduction needed and the targeted load of fecal coliform to be reduced. The current load was calculated using the median flow in the higher (0 – 30 percentile) flow intervals of the LDC multiplied by the highest instream concentration in this flow interval. The 99% reduction was applied to the current load to determine load of fecal coliform that needs to be reduced (Table 4-5).

Table 4-5. Fecal Coliform Reduction Target

Stream (Segment)	Current Fecal Coliform Load (cfu/day)	Target Percent Reduction	Target Fecal Coliform Load to be Reduced (cfu/day)
Upper Big Muddy River (IL_N-11)	6.71E+13	95.6%	6.41E+13
Middle Fork Big Muddy River (IL_NH-06)	9.38E+13	99%	9.29E+13

Based on estimated fecal coliform loads calculated from livestock data, available monitoring data from permitted sewage treatment plants and a conversation with the local health department regarding septic systems, it is likely that the most significant source of fecal coliform loads is agricultural runoff from land with livestock. Fecal coliform loads generated from livestock (cattle, hogs, and turkeys) within the subwatershed that drains to the IL_N-11 segment are estimated to be 6.9E+15 cfu/yr. (1.9E+13 cfu/day), supporting the conclusion that this source may be significant, particularly if it can be transported to the streams with runoff during rainfall. Within the subwatershed that drains to the IL_N-11 segment, septic systems or surface discharging systems in need of repair may also contribute bacteria loads, with an estimated load of 3.3E+15 cfu/yr. (9.0 E+12 cfu/day). This is based on an average density of 1 house per 3 acres in the low and medium density residential areas outside of the boundaries of Christopher, and Zeigler.

Fecal coliform loads generated from livestock ((cattle, hogs, and turkeys within the watershed that drains to the IL_NH-06 segment are estimated to be 1.8E+16 cfu/yr. (5.0E+13 cfu/day), supporting the conclusion that this source may be significant, particularly if it can be transported to the streams with runoff during rainfall. Within the watershed that drains to the IL_N-11 segment, septic systems or surface discharging systems in need of repair may also contribute bacteria loads, with an estimated load of 4.3E+15 cfu/yr. (1.2E+13 cfu/day). This is based on an average density of 1 house per 3 acres in the low and medium density residential areas outside of the boundaries of Benton, Hanaford, and Ewing.

4.2 Potential Management Practices

The TMDLs and LRSs defined necessary load reductions needed to meet targets. The previous section described the sources that should be targeted preferentially to achieve the largest reductions. There are many potential management measures that could be implemented to reduce pollutant loads. Local officials were contacted to assess which practices would be the best fit for the Upper Big Muddy River watershed, recognizing runoff is a predominant pollutant source. These are described below along with other potential management practices commonly used in Illinois. These are:

- Streambank Stabilization
- Conservation Tillage
- Conservation Buffers
- Cover Crops
- Treatment Wetlands
- Nutrient Management Plans
- Livestock Management Controls
- Sediment Control Basins (includes terraces, dry dams, ponds and water & sediment control basins)
- Septic System Maintenance
- Connections to municipal sewer system
- Phosphorus Inactivation

Each of these is briefly described below.

4.2.1 Streambank Stabilization

Streambank erosion is prevalent within the Upper Big Muddy River watershed, and significant portions of the sediment load to the waterbodies with sediment LRSs is estimated to originate from this source based on Model My Watershed calculations described in Section 3. Bank erosion can be caused by erosive streamflow, and one way to address streambank erosion is to reduce peak runoff flows using some of the measures described previously in this section. Erosion can also be addressed by stabilizing streambanks. There are many options for streambank stabilization, ranging from vegetating the banks (e.g., using willows and seed), to heavy armoring using rocks and rip-rap.

The willow-post method for streambank stabilization has been described by the Illinois State Water Survey (ISWS) in Miscellaneous Publication 130. This method uses native willow cuttings to stabilize eroding streambanks. The willow roots work to bind the soil together and the foliage slows floodwaters near the eroding bank. ISWS reports that this method has been used most successfully along streams in agricultural floodplains without tree cover, and that it is most effective when erosion control is implemented on land upstream of the eroded bank. "On land sloping more than 2%, reduced till and no-till farming should be practiced. Pasture and timber areas on steep slopes should be managed for adequate vegetative cover in order to slow water runoff." Dense tree cover can prevent groundcover growth, so vegetation should not be used for streambank stabilization in heavily shaded, wooded areas. An additional consideration is that vegetation is very hard to establish on banks that are frequently wet.

Costs are highly variable depending on a variety of site-specific factors. Installation costs for the willow-post method range from $7 to $15 per foot, with little or no maintenance. These costs are low compared to 'traditional methods' that rely on riprap, cement or steel retaining structures. ISWS reports costs for traditional methods ranging from $50 to $200 per foot, and notes that these require maintenance and repair through the year. Illinois NRCS Engineering Standard Drawings for Streambank Stabilization can be found online at:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/il/technical/engineering/?cid=nrcs141p2_030565

4.2.2 Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (Simmons and Nafziger, undated). This reduction in erosion also reduces the amount of phosphorus lost from the land and delivered to the streams. The NRCS has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (Simmons and Nafziger, undated). Conservation tillage/crop residue management systems are recognized as a cost-effective means of significantly reducing soil erosion and maintaining productivity.

Corn accounts for around 45% of the crop production in the Upper Big Muddy River watershed and soybeans account for around 44%. The remainder is primarily a double crop of winter wheat/soybeans. Based on Illinois Department of Agriculture Soil Conservation Transect Survey Report results for 2013, weighted by county for the watershed, approximately 55% of corn is conventionally tilled. Roughly three-quarters (74%) all of the soybeans have some form of conservation tillage. Conventional tillage has a higher soil loss rate than other forms of conservation tillage for both corn and soybeans.

The implementation of additional conservation tillage measures for corn and soybeans is expected to result in reduced phosphorus and sediment loss. In systems where surface soil test phosphorus values are within recommended ranges, researchers have found that total phosphorus export from no-till fields may be reduced up to 67% when compared to conventional tillage due to the reduction in sediment load and associated phosphorus (DeLaune & Sij, 2012). The Illinois Nutrient Loss Reduction Strategy estimates phosphorus loss is decreased by 50% if reduced tillage is applied to soils which were experiencing soil losses greater than "T", the tolerable soil loss (IDOA and IEPA, 2015). However, fields which are losing soil in excess of "T" tend to be more sloped than the flat soils found in the study watersheds. In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006).

Total sediment loss from no till is 78% less than conventional till (DeLaune & Sij, 2012). A range of estimates are available for assessing the costs of moving to a no-till system. The Illinois Nutrient Loss Reduction Strategy assigns savings of $17/acre when moving from conventional to reduced tillage (IDOA and IEPA, 2015). Soil and Water Conservation District (SWCD) estimates from another region of Illinois indicate the cost of no till and strip till is $33.33/acre, but costs were not provided for mulch-till. Overall, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (Simmons and Nafziger, undated).

4.2.3 Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants, generally by slowing the rate of runoff, while filtering sediment and nutrients as well as other pollutants. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. The total cost of buffers presented in the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015), taking costs related to lost income potential, planting and maintenance is $294/acre.

Based on the NHD high-resolution flowlines (streams), there are roughly 705 miles of streams in the Upper Big Muddy River watershed. A GIS analysis was conducted to identify stream lengths that already have some sort of buffer, and found that 398 miles of streams are already buffered by vegetation (forest, trees, wetlands), indicating 307 miles of streams (43.5% of the stream miles in the watershed) could benefit from this control. Within those 307 miles, the largest adjacent land uses noted are cultivated crops (120 miles) and pasture/hay (142 miles), with approximately 8 miles adjacent to developed land uses, and 21 miles adjacent to developed open land.

Filter strips and similar vegetative control methods can be very effective in trapping sediment and nutrients, and reducing the velocity of runoff flow, allowing greater infiltration of dissolved pollutants. According to the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015), the total phosphorus reduction per acre for buffers on cropland ranges from 25 to 50%, with a median removal rate of 37.5%. According to an Illinois EPA fact sheet[3], the sediment reduction per acre for buffers ranges from 70 to 95%, with an average removal rate of 82.5%. One study of vegetated buffers to reduce fecal coliform bacteria runoff from dairy pastures (Downing and Gamroth, 2007) found that the presence of a vegetated buffer of any size generally reduced the median bacteria concentration in runoff by more than 99%.

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Partners for Conservation Fund, provides cost sharing for conservation practices including field borders and filter strips[4] . The Department of Agriculture distributes funding for the cost-share program to Illinois' Soil and Water Conservation Districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever[5], VIEW guides a committee of local stakeholders through a watershed landscape planning process. Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

3 http://www.epa.state.il.us/water/conservation/lake-notes/shoreline-buffer.pdf
4 http://www.agr.state.il.us/C2000
5 http://www.treesforever.org/Illinois_Buffer_Partnership

4.2.4 Cover Crops

Cover crops are grasses, legumes, rye or forbs that are planted seasonally to cover soil when it would usually be bare (Miller et al., 2012; IDOA and IEPA, 2015). While these crops are not usually sold or utilized agronomically, they have other benefits which make them useful to producers. Cover crops are planted for a variety of purposes including erosion reduction from wind and water, increasing soil organic matter and capturing, recycling, or redistributing excess soil nutrients. Cover crops can benefit water quality through three pathways – by increasing the soil's ability to infiltrate rainfall, by scavenging and taking up nutrients, and by intercepting raindrop impact in order to reduce soil crusting and erosion (Miller et al., 2012).

Cover crops effectively reduce both nitrate-nitrogen and total phosphorus losses while also improving soil tilth and other important properties (IDOA and IEPA, 2015). The Illinois Nutrient Loss Reduction Strategy indicates cover crops can reduce total phosphorus by 30% per acre (IDOA and IEPA, 2015). According to IDOA and IEPA, 2015, cover crops may introduce additional management challenges, particularly in adverse years. Establishing cover crops may be difficult in years with dry summers and falls. Cover crop planting and termination operations may also introduce logistical issues on farms. Landowners and producers in the watershed are encouraged to work with their local agronomist, certified crop advisor, or seed retailer to determine the type of cover crops that would best suit their soil types and cropping operations. Based on the Illinois EQIP payment schedule[6], the cost of cover crops ranges from $36.24 to $88.10/acre. An average cost of $63.16 is assumed in this implementation plan.

4.2.5 Treatment Wetlands

Soils in the Upper Big Muddy River watershed are poorly drained and drainage has likely been enhanced using tile drains in agricultural areas in much of the watershed. The exact areas with tile drains is unknown.

Treatment wetlands have been shown to be effective at reducing phosphorus from tile drain flow, if they are properly sited and sized. A pilot study on an experimental farm indicates that treatment wetlands that intercepted tile drains removed approximately 47-57 percent of the total phosphorus from water (IDOA and IEPA, 2015).

According to IDOA and IEPA (2015), the reduction practice is the construction of 5 acres of wetland for every 100 acres of production, and costs are $60.63/acre/yr. if a wetland is assumed to provide treatment for 20 years, the farmland taken out of production is charged against the remaining cropland, and $3 per acre yearly maintenance cost. Using the reported total costs (IDOA & IEPA, 2015), inclusive of the per acre purchase price, and dividing the total out over 20 years produces annual costs of $683/acre. Of note, this practice represents a large decrease in income-generating potential if the acreage taken out of cropland was agronomically productive ground.

4.2.6 Nutrient Management Plans

Nutrient management plans are designed to minimize nutrient losses from agricultural lands and improve nutrient use efficiency of the crop, and therefore minimize the amount of phosphorus transported to waterbodies. Because agriculture is the most common land use in the watershed (roughly 90%), controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the streams. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (USEPA, 2003).

Nutrient management is defined as managing the amount, source, placement, form, and timing of plant nutrients and soil amendments (NRCS Illinois, 2013). The NRCS Practice Standard for nutrient

[6] https://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/

management notes that this practice applies on all lands where plant nutrients and soil amendments are applied. Additional details regarding nutrient management are provided in the NRCS Illinois Practice Standard (NRCS Illinois, 2013 and chapter 8 of the Illinois Agronomy Handbook (Fernandez and Hoeft, undated), and two example practices are described below.

- Site-specific or variable-rate nutrient application: "This application method uses several remote sensing technologies, yield monitors, global positioning systems, geographical information systems, and variable-rate technology (VRT). These technologies can improve the efficacy of fertilization and promote more environmentally sound placement of fertilizer compared to single-rate applications derived from the conventional practice of collecting a composite soil sample to represent a large area of the field. Research has shown that this technology often reduces the amount of fertilizer applied over an entire field. However, one of the drawbacks of this placement method is the expense associated with these technologies. Also, VRT can only be as accurate as the soil test information used to guide the application rate" (Fernandez and Hoeft, undated).

- Deep fertilizer placement: "With this system any combination of N, P, and K can be injected at a depth of 4 to 8 inches. The knife spacing varies, but generally it is 15 to 18 inches apart for close-grown crops such as wheat and 30 inches for row crops. (Fernandez and Hoeft, undated). This practice may be beneficial (as long as the subsurface band application does not create a channel for water and soil movement) in areas where the potential for surface water runoff is high.

The Illinois Agronomy Handbook (Fernandez and Hoeft, undated) gives a broad overview of phosphorus recommendations in Chapter 8. For producers in the Upper Big Muddy River watershed, it is important to keep in mind that they are in a region of "low" available subsoil phosphorus. This means it is recommended that soil test values be built up to 50 pounds per acre (measured by Bray P_1) to ensure corn and soybean crop yields will not be restricted by phosphorus availability (Fernandez and Hoeft, undated). Soils testing between 50 and 70 pounds per acre should have fertilizer applied only in the amount of expected removal of the current crop while soils showing greater than 70 pounds per acre of phosphorus will experience no agronomic advantage in additional application (Fernandez and Hoeft, undated).

Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil where it is subject to transport (NRCS, 2006). Tillage will incorporate this surface-applied fertilizer; however a no-till system will leave the phosphorus on the surface. In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality. It is recommended that nutrient management plans be developed and implemented based on soil testing conducted at least every four years and applied to all cropland acres in the watershed.

The approximate cost of developing ($4/acre) and implementing ($12/acre) a nutrient management plan totals $16/acre. This cost may be offset in part by savings associated with using less fertilizer. For example, a study in Iowa showed that improved nutrient management on cornfields led to a savings of about $5/acre (EPA, 2003).

Phosphorus rate reduction resulting from implementation of nutrient management plans was estimated to reduce TP export by 7%. This estimate was provided by the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015).

4.2.7 Livestock Management Controls

BMPs to reduce fecal coliform from livestock include activities on the grounds to manage manure and reduce runoff and the proper siting, construction and management of lagoons, settling basins and holding ponds, to reduce groundwater and surface water impacts. Land application of manure can be environmentally beneficial, and a few examples of land application BMPs to reduce nutrient and bacteria runoff include: development of a manure management plan, scheduling application times that are compatible with crop rotations, having sufficient land available to land apply, locating land application sites away from valleys, and applying manure on fields that are not highly erodible. Many more examples can be found on-line[7]. There are a large number of EQIP-eligible conservation practices for confined livestock and manure management, as well as grazing land operations, including ponds (payment cap of $20,000 per pond), roofs and covers (payment cap of $100,000), and fencing (no payment cap listed).[8]

In addition to manure management and runoff reduction from livestock areas, the appropriate management of pasture or grazing-based livestock production can minimize nutrient and fecal coliform losses by eliminating uncontrolled livestock access to streams, providing shade and water sources away from streams, and maintaining healthy grass stands that reduce runoff (IDOA and IEPA, 2015). Fencing, together with the development of alternate watering systems can help restrict livestock access to streams. . USEPA (2003) reports that livestock exclusion from waterways and other grazing management measures could reduce fecal coliform counts by 29% to 46% percent. Farm ponds can be designed to capture runoff and provide water for livestock. When installed in line with the stream, ponds can reduce sediment, nutrient and bacteria loading. Fencing should be placed outside of the filter strip/riparian area. Wildlife access is harder to restrict with fencing and buffers that filter runoff are likely to be more effective than measures aimed at restricting wildlife access to the streams. Fencing costs are variable, and based on the Illinois EQIP and RCPP-EQIP payment schedule[7], can range from $0.79/foot to $4.89/foot. An average cost of $2.02/foot is assumed for this implementation plan.

4.2.8 Sediment Control Basins (includes terraces, dry dams, ponds and water & sediment control basins (WASCOB))

Sediment control basins are defined here to include water and sediment control basins, terraces, dry dams, and ponds and are designed to trap sediments prior to reaching a receiving water. Sediment control basins trap runoff and the associated sediment load from upgradient areas, slowing runoff and reducing gully erosion. Water is released slowly, reducing peak runoff flows and streamflow erosivity/streambank erosion.

Sediment control basins are usually designed to capture drainage from an area of 30 acres or less and should be large enough to control runoff from at least a 10-year, 24-hour storm. The local NRCS is a great resource for information regarding design, installation and funding. Replanting or reseeding may be needed to maintain vegetation, and trapped sediment may need to be periodically removed. Locations are determined based on slopes, tillage, and crop management, and the local NRCS can often provide information and advice for design and installation.

Terracing implemented on steeper slopes can reduce runoff flow volume and velocity, as well as soil erosion. Terrace systems have been shown to remove as much as 85 percent of sediment and 70 percent of total phosphorus from runoff (USEPA 2003).

4.2.9 Septic system maintenance

Routine maintenance of a septic system can extend the life of the system, and prevent failure and ultimately replacement. To keep a septic tank in good working order, routine cleanings should be scheduled every two to three years with a reputable provider. The cost to pump a typical septic tank is variable, but on average costs approximately $250, depending on the number of gallons pumped and the disposal fee for the area. This is much less than the cost of installing a new system ($8,000 - $10,000).

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[7] http://www.epa.illinois.gov/topics/pollution-prevention/fact-sheets/bmp-pork/index and http://web.extension.illinois.edu/sfmm/beef.cfm

[8] https://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/

Health departments typically provide inspection of new system installations, septic system permits, and provide homeowner problem consultation/complaint investigations, and may be a good resource for disseminating information on septic system maintenance. The National Small Flows Clearinghouse is another good resource for information on septic systems. http://www.nesc.wvu.edu/subpages/septic.cfm

4.2.10 Connections to municipal sewer systems

In the subwatersheds with fecal coliform TMDLs, connecting residences to municipal sewer system should be investigated in areas surrounding the municipalities with POTWs. This will help to reduce the fecal coliform loads from poorly performing septic systems in areas where it is a feasible option. The following communities have municipal sewer systems within or near the watershed of the Middle Fork Big Muddy River (IL_NH-06) which is impaired for fecal coliform:

- City of Benton
- Village of Hanaford.

The following communities have municipal sewer systems within or near the watershed of the Middle Fork Big Muddy River (IL_N-11)

- City of Zeigler
- City of Orient
- City of West Frankfort
- City of Christopher

The ability to extend sewer service from these municipalities will depend on the existing capacity of the plant, the plans for future growth, and the cost of extending the sewer system and adding additional treatment capacity, if necessary. In addition, it may require additional inter-governmental agreements if sewer service is extended beyond municipal boundaries. The costs for this option are highly variable, depending on the distance that sewers would need to be extended, the available treatment capacity, and the number of properties that could be connected to the sewer system. Typical costs for extending sewer service range from $10,000 to $20,000 per home.

4.2.11 Phosphorus Inactivation

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments (McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient. If watershed sources are not controlled, repeated treatments will be needed. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years. Studies have indicated that the effectiveness of alum at controlling internal phosphorus loading in stratified lakes averaged 80% over several years of observation (Welch and Cooke, 1999). Costs for phosphorus inactivation are approximately $1,300 to $1,600 per acre (Sweetwater, 2006). This alternative is recommended in concert with other watershed load reductions.

4.3 Summary of Management Measure Applicability

Many management measures are available for reducing pollutant loads. Table 4-6 below summarizes the identified measures and provides an assessment of potential applicability for this watershed based on similar measures adopted in other watersheds, and feedback from local agencies.

Table 4-6. Assessment of Management Measure Applicability for Upper Big Muddy River Watershed

Management Measure	Currently used?	Potential within Upper Big Muddy River watershed
Conservation tillage	Unknown	High potential - Commonly used in agricultural areas across Illinois. Larger potential for pollutant reductions in Hamilton, Jefferson and Franklin Counties due to lower adoption rate.
Conservation buffers	Unknown	High potential - Commonly used in agricultural areas across Illinois
Cover crops	Unknown	High potential - Commonly used in agricultural areas across Illinois. Great potential for expanding cover crops
Treatment wetlands	Unknown	Unknown
Nutrient management plans	Unknown	High potential - Commonly used in agricultural areas across Illinois.
Livestock management controls	Unknown	High potential, high cost may be a hurdle.
Sediment basins	Unknown	High potential. See ~90% flow reduction
Streambank stabilization	Unknown	High potential. Rock is preferred. Willow posts not popular
Septic system maintenance	Unknown	Unknown – depends on failure rate, and implementation or programs to regularly inspect and maintain systems, such as point-of-sale inspections.
Connection to municipal sewer system	Unknown	Unknown – depends on available capacity, cost to connect, and governmental agreements to extend service.
Phosphorus Inactivation	Unknown	High potential – needs detailed investigation in lakes before it can be implemented.

4.4 Recommended Management Measures

Based on the preceding information, recommended non-point source management measures to reduce pollutant loading in the Upper Big Muddy River watershed are discussed in the following sections by subwatershed.

4.4.1 Big Muddy River (IL_N-06)

The non-point source sediment load reduction target for this segment of the Big Muddy River is 26.2% and will require implementation of management measures to reduce sediment from agricultural runoff and streambank erosion, including the following:

- ***Conservation Tillage*** – Of the 4,646 acres of cultivated cropland, roughly 4,135 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on 75% of the conventionally tilled acres (1,261 acres), this would reduce sediment loading in this subwatershed by approximately 9% of the total sediment load.
- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 31.6 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on 50% of all currently unbuffered streams would add buffers to 4.92 miles of stream (20.9 acres), controlling about 5% of runoff from agricultural land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in this subwatershed by approximately 2%.
- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 41.5 miles of streams in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 29% of the eroding streambanks (12 miles) would reduce sediment loads to the target of 26.2%.

4.4.2 Big Muddy River (IL_N-11)

The non-point source sediment load reduction target for this segment of the Big Muddy River is 39.3% and will require aggressive implementation of management measures to reduce sediment from agricultural runoff and streambank erosion. In addition, this river segment has a required fecal coliform load reduction of 95.6% during wet weather flows. Recommended management measures to address the non-point sources of these pollutants include the following:

- ***Conservation Tillage*** – Of the 5,775 acres of cultivated cropland, roughly 5,140 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on 75% of the conventionally tilled acres (1,567 acres), this would reduce sediment loading in this subwatershed by approximately 16% of the total sediment load.
- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 71.6 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on 50% of all currently unbuffered streams would add buffers to 29.5 miles of stream (125 acres), controlling about 28% of runoff from agricultural land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in this subwatershed by approximately 19%.

One study of vegetated buffers to reduce fecal coliform bacteria runoff from dairy pastures (Downing and Gamroth, 2007) found that the presence of a vegetated buffer of any size generally reduced the median bacteria concentration in runoff by more than 99%. Adding conservation buffers on these streams acres are calculated to reduce current fecal coliform loads by 27%.

- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 130.5 miles of streams in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 20% of the eroding streambanks (26.1 miles) would reduce total watershed sediment loads to the target of 39.3%.

- ***Restrict Livestock Access to Stream:*** The extent to which livestock currently have access to the Big Muddy River and its tributaries within this subwatershed is unknown, although a GIS analysis indicates there are 26 stream miles traversing land with pasture/hay. For this analysis, it was assumed the livestock are located on pasture/hay land only, although field reconnaissance is recommended to identify pasture/hay land that currently support livestock with stream access. Restricting livestock access to the creeks will not only reduce bacteria loads, but will also reduce streambank erosion. USEPA (2003) reports that livestock exclusion from waterways and other grazing management measures could reduce fecal coliform counts by 29% to 46% percent. Fecal loads delivered to the streams within this subwatershed generated by cattle and hogs can be estimated using literature values, county-wide livestock counts, and assumptions regarding their distribution. If these loads are reduced by 29% (to be conservative), adding fencing 20 miles of streams could reduce fecal coliform loads by 8%. This value is highly uncertain because current livestock access to the Middle Fork Big Muddy River and its tributaries is unknown.

- ***Septic maintenance:*** Maintenance of septic systems can ensure they are performing as designed, and do not contribute bacteria or other pollutants to local waterways. If all low and medium intensity development (291 acres) is assumed to be serviced by onsite systems, and it is assumed that there is one house/3 acres, then there are an estimated 97 onsite systems in the Big Muddy River IL_N-11 subwatershed. Assuming a failure rate of 5%, then approximately 5 systems would be in need of maintenance or repair. If these were contributing a volume of 90 gallons/person/day for 2.5 people/household, with a raw sewage concentration of 5.01E+07 cfu/100 ml, the load generated would equal 7.5E+14 cfu/yr. Maintenance of failing systems would eliminate this load, reducing current loads by 3% (assuming assumptions regarding this load are accurate).

If fully implemented, these measures would results in an estimated 38% fecal coliform load reduction. Attainment of a 95.6% reduction may not be feasible without a more detailed investigation of sources and targeted controls on the largest contributing sources. Additional monitoring during both dry and wet weather to identify locations of high fecal coliform bacteria counts are recommended to help further identify specific sources and locations within the watershed where BMPs should be focused.

4.4.3 Big Muddy River (IL_N-17)

The non-point source sediment load reduction target for this segment of the Big Muddy River is 70.8% and will require aggressive implementation of management measures to reduce sediment from agricultural runoff and streambank erosion, including the following:

- ***Conservation Tillage*** – Of the 8,137 acres of cultivated cropland, roughly 7,242 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on 100% of the conventionally tilled cropland (2,945 acres), this would reduce sediment loading in this subwatershed by approximately 18% of the total sediment load.

- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 34.2 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on all currently unbuffered streams would add buffers to 13.7 miles of stream (58 acres), controlling about 9% of runoff from agricultural land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in this subwatershed by approximately 6%.
- ***Cover Crops*** – The quantity of land draining directly to the Big Muddy River IL_N-17 segment and its tributaries managed using cover crops is not known, but is assumed to be 10% or less for this plan. If cover crops are added to the management of the remaining 90% of agricultural land (7,323 acres), with an estimated sediment reduction rate of 50%, the watershed sediment load can be reduced another 29%.
- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 47.9 miles of streams and rivers in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 87% (41.7 miles) of the eroding streambanks within the watershed would reduce sediment loads in this subwatershed an additional 17%, which combined with the management measures identified meets the target identified above.
- ***Sediment Basins***– If the common management measures described above are implemented in the Big Muddy River (IL_N-17) watershed, at the aggressive levels of implementation described, their combined, estimated sediment load reduction will reach the 70.8% target identified above. If there are areas where the measures described above are not able to be implemented, the remaining load would have to be controlled by other means and of the measures described here, the most effective would be sediment basins. During implementation of the measures described here, additional monitoring should be performed to ensure that the target reduction is met. If additional load reductions are required, installing sediment basins to control runoff from agricultural and developed lands should be considered.

This segment is the downstream portion of the watershed in consideration for study as well. Following the implementation of conservation tillage, streambank stabilization, cover crops, and conservation buffers within this subwatershed, implementation of addition sediment reduction measures upstream may also reduce the sediment load in this river segment to meet the TSS LRS target.

4.4.4 Pond Creek (IL_NG-02)

The non-point source sediment load reduction target for this segment of Pond Creek is 62.7% and will require aggressive implementation of management measures to reduce sediment from agricultural runoff and streambank erosion, including the following:

- ***Conservation Tillage*** – Of the 6,407 acres of cultivated cropland, roughly 5,702 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on 100% of the conventionally tilled cropland (2,319 acres), this would reduce sediment loading in this subwatershed by approximately 14% of the total sediment load.

- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 52.71 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on all currently unbuffered streams would add buffers to 37.7 miles of stream (160 acres), controlling about 22% of runoff from agricultural land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in this subwatershed by approximately 14%.

- ***Cover Crops*** – The quantity of land in the Pond Creek watershed managed using cover crops is not known, but is assumed to be 10% or less for this plan. If cover crops are added to the management of the remaining 90% of agricultural land (5,767 acres), with an estimated sediment reduction rate of 50%, the watershed sediment load can be reduced another 22%.

- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 90.4 miles of streams and rivers in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 66% (59.7 miles) of the eroding streambanks within the watershed would reduce sediment loads in this subwatershed an additional 13%, which combined with the management measures identified above will meet the target load reduction of 62.7%.

- ***Sediment Basins***– If the common management measures described above are implemented in the Pond Creek watershed, at the aggressive levels of implementation described, their combined, estimated sediment load reduction will reach the 62.7% target. If there are areas where the measures described above are not able to be implemented, the remaining load would have to be controlled by other means and of the measures described here, the most effective would be sediment basins. During implementation of the measures described here, additional monitoring should be performed to ensure that the target reduction is met. If additional load reductions are required, installing sediment basins to control runoff from agricultural and developed lands should be considered.

4.4.5 Middle Fork Big Muddy (IL_NH-07)

The non-point source sediment load reduction target for this segment of the Middle Fork of the Big Muddy River is 55.5% and will require aggressive implementation of management measures to reduce sediment from agricultural runoff and streambank erosion, including the following:

- ***Conservation Tillage*** – Of the 30,226 acres of cultivated cropland, roughly 26,901 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on all of the conventionally tilled acres (10,939 acres), this would reduce sediment loading in this subwatershed by approximately 15% of the total sediment load.

- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 88.6 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on 100% of all currently unbuffered streams would add buffers to 82.6 miles of stream (351 acres), controlling about 14% of runoff from agricultural land. At a median removal effectiveness of 82.5%, this would reduce total sediment loading in this subwatershed by approximately 6%.

- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 171.2 miles of streams in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 78% of the eroding streambanks (133.6 miles) would reduce sediment loads to the target of 55.5%.

4.4.6 Beaver Creek (IL_NGAZ-JC-D1)

The non-point source manganese load reduction target for this segment of Beaver Creek is 24.4%. Because of the prevalence of manganese in the local soils, BMPs implemented to address the manganese impairment will be designed to reduce soil erosion, and will require aggressive implementation of management measures to reduce sediment from agricultural runoff and streambank erosion, including the following:

- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 1.37 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on all currently unbuffered streams would add buffers to 0.31 miles of stream (25 acres), controlling about 15% of runoff from agricultural/pasture/hay land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in this subwatershed by approximately 12%.

- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 1.68 miles of streams and rivers in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the sediment load from the target bank, implementation of streambank stabilization on 100% of the eroding streambanks within the watershed would reduce sediment loads in this subwatershed an additional 5%, which combined with the management measures identified above 16.9%, which is significantly below the target identified above.

- ***Sediment Basins***– If the common management measures described above are implemented in the Pond Creek watershed, at the aggressive levels of implementation described, their combined, estimated manganese/sediment load reduction will be would fall short of the 24.4% target by 7.5%. This remaining load would have to be controlled by other means and of the measures described here, the most effective would be sediment basins. Sediment basins are estimated to have a sediment removal effectiveness of 85%. To achieve the additional 7.5% manganese/sediment reduction, sediment basins would be needed to treat runoff from roughly 9% (15 acres) of pasture/hay, agricultural, and developed land in the subwatershed.

4.4.7 Andy Creek (IL_NZN-13)

The non-point source iron load reduction target for this segment of Andy Creek is 9%. Because of the prevalence of iron in the local soils, BMPs implemented to address the iron impairment will be designed to reduce soil erosion, and will aggressive implementation of management measures to reduce sediment from agricultural runoff to meet the required reduction target, including the following:

- ***Conservation Tillage*** – Of the 3,548 acres of cultivated cropland, roughly 3,158 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated reduction efficiency of 78% were implemented on 50% of the conventionally tilled land (642 acres), this would reduce sediment loading in this subwatershed by approximately 8% of the total sediment load.

- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 16.4 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on 25% of currently unbuffered streams would add buffers to 3.16 miles of stream (13.4 acres), controlling about 4% of runoff from agricultural/pasture/hay land. At a median removal effectiveness of 82.5%, this would reduce sediment loading in this subwatershed by approximately 2%. Combined with the conservation tillage noted above, this is enough to meet the target reduction in this subwatershed.

4.4.8 Middle Fork Big Muddy (IL_NH-06)

The non-point source fecal coliform load reduction target for the Middle Fork Big Muddy River watershed varies from 88-99% over a range of flows, with the highest reduction required at the higher flows. Attainment of this target will require aggressive implementation of management measures to reduce fecal coliform bacteria from nonpoint source runoff, including the following:

- ***Conservation buffers:*** One study of vegetated buffers to reduce fecal coliform bacteria runoff from dairy pastures (Downing and Gamroth, 2007) found that the presence of a vegetated buffer of any size generally reduced the median bacteria concentration in runoff by more than 99%. 49% (41.8 miles) of the streams in the Middle Fork Big Muddy River watershed are currently without a buffer. Buffers on these streams controlling are calculated to reduce current fecal coliform loads by 48%. Assuming that conservation buffers are 35 feet wide, the area of buffers added will be 178 acres.
- ***Restrict Livestock Access to Stream:*** The extent to which livestock currently have access to the Middle Fork Big Muddy River and its tributaries within this subwatershed is unknown, although a GIS analysis indicates there are 20 stream miles traversing land with pasture/hay. For this analysis, it was assumed the livestock are located on pasture/hay land only, although field reconnaissance is recommended to identify pasture/hay land that currently support livestock with stream access. Restricting livestock access to the creeks will not only reduce bacteria loads, but will also reduce streambank erosion. USEPA (2003) reports that livestock exclusion from waterways and other grazing management measures could reduce fecal coliform counts by 29% to 46% percent. Fecal loads delivered to the streams within this subwatershed generated by cattle and hogs can be estimated using literature values, county-wide livestock counts, and assumptions regarding their distribution. If these loads are reduced by 29% (to be conservative), adding fencing 20 miles of streams could reduce fecal coliform loads by 14%. This value is highly uncertain because current livestock access to the Middle Fork Big Muddy River and its tributaries is unknown.
- ***Septic maintenance:*** Maintenance of septic systems can ensure they are performing as designed, and do not contribute bacteria or other pollutants to local waterways. If all low and medium intensity development (1,621 acres) is assumed to be serviced by onsite systems, and it is assumed that there is one house/3 acres, then there are an estimated 540 onsite systems in the Middle Fork Big Muddy River watershed. Assuming a failure rate of 5%, then 27 systems would be in need of maintenance or repair. If these were contributing a volume of 90 gallons/person/day for 2.5 people/household, with a raw sewage concentration of 5.01E+07 cfu/100 ml, the load generated would equal 4.2E+15 cfu/yr. Maintenance of failing systems would eliminate this load, reducing current loads by 12% (assuming assumptions regarding this load are accurate).

If fully implemented, these measures would results in an estimated 74% fecal coliform load reduction. Attainment of a 99% reduction may not be feasible without a more detailed investigation of sources and targeted controls on the largest contributing sources. Additional monitoring during both dry and wet weather to identify locations of high fecal coliform bacteria counts are recommended to help further identify specific sources and locations within the watershed where BMPs should be focused.

4.4.9 Herrin Old Reservoir (IL_RNZD)

The BATHTUB modeling of the Herrin Old Reservoir indicated that the primary source of the phosphorus that is impairing the waterbody is the release of phosphorus from sediment that has accumulated in the reservoir. Without removing this source of phosphorus, the waterbody will not be able to reach compliance with the water quality standards, even with reductions in the watershed loads. The internal phosphorus source needs to be address, either through phosphorus inactivation or dredging and removal of the sediment. For the purposes of this report, phosphorus inactivation of the sediments using alum is considered, however, prior to implementation, the reservoir owner may consider sediment removal as an alternative.

- ***Phosphorus Inactivation***– To inactivate the phosphorus contained in the water column and sediment within the reservoir, the entire surface area of the lake will need to be treated with alum, or some other phosphorus binding agent. This reservoir has a surface area of 51.3 acres that need to be treated.

4.4.10 Johnston City Reservoir (IL_RNZE)

The BATHTUB modeling of the Johnston City Reservoir indicated that the primary source of the phosphorus that is impairing the waterbody is the release of phosphorus from sediment that has accumulated in the reservoir. Without removing this source of phosphorus, the waterbody will not be able to reach compliance with the water quality standards, even with reductions in the watershed loads. The internal phosphorus source needs to be address, either through phosphorus inactivation or dredging and removal of the sediment. For the purposes of this report, phosphorus inactivation of the sediments using alum is considered, however, prior to implementation, the reservoir owner may consider sediment removal as an alternative.

- ***Phosphorus Inactivation***– To inactivate the phosphorus contained in the water column and sediment within the reservoir, the entire surface area of the lake will need to be treated with alum, or some other phosphorus binding agent. This reservoir has a surface area of 64 acres that need to be treated.

4.4.11 Arrowhead Reservoir (Williamson) (IL_RNZX)

The non-point source total phosphorus load reduction target for this lake is 30%, in addition to the elimination of the internal phosphorus source from lake sediments. In the watershed that drains to the Arrowhead Reservoir, the ModelMyWatershed model results show that majority of the phosphorus load is from runoff from pasture/hay fields. There are no defined streams within the NHD dataset, which limits the applicability of conservation buffers and streambank stabilization in this watershed. The most applicable BMP in this small watershed is to install treatment wetland or sediment basins downstream of the hay/pasture and agricultural lands to remove the phosphorus.

- ***Phosphorus Inactivation***– To inactivate the phosphorus contained in the water column and sediment within the reservoir, the entire surface area of the lake will need to be treated with alum, or some other phosphorus binding agent. This reservoir has a surface area of 30 acres that need to be treated.
- ***Treatment Wetlands or Sediment Basins***– The 30% phosphorus load reduction will have to be controlled by sediment basins or treatment wetlands. Sediment basins are estimated to have a phosphorus removal effectiveness of 70% and wetlands are estimated to have a median phosphorus

removal effectiveness of 52%. To achieve the 30% phosphorus reduction, sediment basins would be needed to treat runoff from roughly 45% (106 acres) of the hay/pasture and agricultural land in the watershed. Alternatively, treatment wetlands will be needed for treat runoff from roughly 61% (142 acres) of hay/pasture and agricultural land in the subwatershed. If space is available, an in-lake sedimentation basin could be implemented to capture and treat runoff before it reaches the main body of the lake.

4.4.12 West Frankfort Old Reservoir (IL_RNP)

The average annual phosphorus load reduction from non-point sources for the West Frankfort New Reservoir is 75%, in addition to the elimination of the internal phosphorus source from lake sediments. This is a very high phosphorus load reduction target, which will required aggressive implementation of management measures to reduce phosphorus from agricultural runoff and streambank erosion, including the following:

- ***Phosphorus Inactivation***– To inactivate the phosphorus contained in the water column and sediment within the reservoir, the entire surface area of the lake will need to be treated with alum, or some other phosphorus binding agent. This reservoir has a surface area of 146 acres that need to be treated.

- ***Conservation Tillage*** – Of the 682 acres of cultivated cropland in this watershed, roughly 314 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated phosphorus load reduction efficiency of 67% were implemented on all of the conventionally tilled land (114 acres), this would reduce phosphorus loading in this subwatershed by approximately 11%.
- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 2.44 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on all currently unbuffered streams would add buffers to 1.82 miles of stream (8.44 acres), controlling about 12% of runoff from agricultural/pasture/hay land. At a median removal effectiveness of 37.5%, this would reduce phosphorus loading in this subwatershed by approximately 3%.
- ***Cover Crops*** – The quantity of land in the West Frankfort New Reservoir watershed managed using cover crops is not known, but is assumed to be 10% or less for this plan. If cover crops are added to the management of the remaining 90% of agricultural land (282 acres), with an estimated phosphorus reduction rate of 30%, the watershed phosphorus load can be reduced another 14%.
- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 4.43 miles of streams and rivers in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the phosphorus load from the target bank, implementation of streambank stabilization on 100% of the eroding streambanks within the watershed, that would reduce sediment loads in this subwatershed an additional 1%, which combined with the management measures identified above would control 27% of the total phosphorus loads, which is significantly below the target identified above.
- ***Treatment Wetlands or Sediment Basins***– The additional 48% phosphorus load reduction necessary to meet the target for this subwatershed will have to be controlled by other means. Of the potential measures described in this report, the most effective would be sediment basins or treatment wetlands. Sediment basins are estimated to have a phosphorus removal effectiveness of 70% and wetlands are estimated to have a median phosphorus removal effectiveness of 52%. To achieve the additional 48% phosphorus reduction, sediment basins would be needed to treat runoff

from roughly 87% (1,178 acres) of the hay/pasture and agricultural land in the watershed. In addition, sediment basins can be used to capture and control sediment from developed land uses as well. Alternatively, treatment wetlands will be needed for treat runoff from a portion of the land, however, since they are less effective at phosphorus removal, additional area would need to be controlled above the 83% identified above. If space is available, an in-lake sedimentation basin could be implemented to capture and treat runoff before it reaches the main body of the lake. Regular maintenance and removal of the captured sediment would be required to maintain the effectiveness of this management measure.

4.4.13 West Frankfort New Reservoir (IL_RNQ)

The average annual phosphorus load reduction from non-point sources for the West Frankfort New Reservoir is 75%. This is a very high phosphorus load reduction target, which will required aggressive implementation of management measures to reduce phosphorus from agricultural runoff and streambank erosion, including the following:

- ***Phosphorus Inactivation***– To inactivate the phosphorus contained in the water column and sediment within the reservoir, the entire surface area of the lake will need to be treated with alum, or some other phosphorus binding agent. This reservoir has a surface area of 214 acres that need to be treated.

- ***Conservation Tillage*** – Of the 682 acres of cultivated cropland in this watershed, roughly 607 acres are corn and soybeans. Of this, roughly 36% of corn and soybean acreage is conventionally tilled. If conservation tillage with an estimated phosphorus load reduction efficiency of 67% were implemented on all of the conventionally tilled land (247 acres), this would reduce phosphorus loading in this subwatershed by approximately 13%.
- ***Conservation Buffers*** – Based on the spatial analysis described above, roughly 5.42 miles of streams in this subwatershed are currently buffered (adjacent to forest or wetlands). Assuming that conservation buffers control runoff from land within an eighth of a mile of the stream, each mile of buffer can control runoff from 80 acres of land. Adding conservation buffers on all currently unbuffered streams would add buffers to 1.82 miles of stream (7.7 acres), controlling about 6% of runoff from agricultural/pasture/hay land. At a median removal effectiveness of 37.5%, this would reduce phosphorus loading in this subwatershed by approximately 2%.
- ***Cover Crops*** – The quantity of land in the West Frankfort New Reservoir watershed managed using cover crops is not known, but is assumed to be 10% or less for this plan. If cover crops are added to the management of the remaining 90% of agricultural land (614 acres), with an estimated phosphorus reduction rate of 30%, the watershed phosphorus load can be reduced another 14%.
- ***Streambank Stabilization*** – The extent of streambank erosion is not known, but it was observed to be prevalent in the watershed. A GIS analysis identified 7.24 miles of streams and rivers in this subwatershed. If it is assumed that streambank stabilization reduces 100% of the phosphorus load from the target bank, implementation of streambank stabilization on 100% of the eroding streambanks within the watershed, that would reduce sediment loads in this subwatershed an additional 2%, which combined with the management measures identified above would control 31.6% of the total phosphorus loads, which is significantly below the target identified above.
- ***Treatment Wetlands or Sediment Basins***– The additional 43.4% phosphorus load reduction necessary to meet the target for this subwatershed will have to be controlled by other means. Of the potential measures described in this report, the most effective would be sediment basins or treatment wetlands. Sediment basins are estimated to have a phosphorus removal effectiveness of 70% and wetlands are estimated to have a median phosphorus removal effectiveness of 52%. To

achieve the additional 43.4% phosphorus reduction, sediment basins would be needed to treat runoff from roughly 83% (1,906 acres) of the hay/pasture and agricultural land in the watershed. In addition, sediment basins can be used to capture and control sediment from developed land uses as well. Alternatively, treatment wetlands will be needed for treat runoff from a portion of the land, however, since they are less effective at phosphorus removal, additional area would need to be controlled above the 83% identified above. If space is available, an in-lake sedimentation basin could be implemented to capture and treat runoff before it reaches the main body of the lake. Regular maintenance and removal of the captured sediment would be required to maintain the effectiveness of this management measure.

4.5 Estimated Costs of Recommended Management Measures

The overall capital costs of implementing the recommended non-point source management measures in the Upper Big Muddy River watershed were estimated on a unit cost basis. Unit costs for on-field or edge-of-field measures were obtained from various sources such as the Illinois Nutrient Loss Reduction Strategy, and where possible, are specific to Illinois.

- ***Conservation Tillage*** – The estimated cost of no till and strip till is estimated to be $33.33/acre.
- ***Conservation Buffers*** – The estimated cost of critical area planting is variable and may be as high as $350/acre. The total cost of buffers presented in the Illinois Nutrient Loss Reduction Strategy (IDOA and IEPA, 2015), taking costs related to lost income potential, planting and maintenance is $294/acre, possibly reflecting geographic variability in farmland value. For purposes of this plan, the higher value of $350/acre is used.
- ***Cover Crops*** – The estimated the cost of cover crops to be $63.16/acre.
- ***Nutrient Management Plans*** – The estimated cost of developing ($4/acre) and implementing ($12/acre) a nutrient management plan totals $16/acre.
- ***Water and Sediment Control Basins*** – According to 2014 Illinois Conservation Partnership Annual Report, constructed wetlands cost $113.79 per acre of land benefited. The average basin was constructed to control an area of approximately 25 acres. Accounting for inflation of approximately 2% per year, a unit cost of $125 per acre of land benefitted was used for estimating the costs in this report.
- ***Constructed Wetlands*** – According to 2015 Illinois Nutrient Loss Reduction Strategy, constructed wetlands cost $60.63/acre/yr. if a wetland is assumed to provide treatment for 20 years, the farmland taken out of production is charged against the remaining cropland, and $3 per acre yearly maintenance cost. Using the reported total costs, inclusive of the per acre purchase price, and dividing the total out over 20 years produces annual costs of $683/acre.
- ***Livestock Management*** – Fencing is assumed to cost $2.02/foot, based on the average cost from the Illinois EQIP and RCPP-EQIP payment schedule.
- ***Streambank Stabilization*** – Streambank stabilization costs vary significantly depending on the method used (e.g., willow post vs. armoring with rock) and site conditions. The cost of $200/foot is used for estimation purposes, but the actual cost will need to be reevaluated based on the site and selected method.
- ***Septic Maintenance*** – The cost to pump a typical septic tank is variable, but on average costs $250, depending on the number of gallons pumped and the disposal fee for the area. New systems can cost between $8,000 and $10,000.

A summary of the proposed management measures proposed for each basin are included below along with the cost estimate for implementation.

Table 4-7. Summary of Proposed Management Measures and Estimated Costs

Waterbody	Recommended Management Measures	Quantity	Units	Unit Cost	Estimated Cost
Big Muddy R. (IL_N-06)	Conservation Tillage	1,261	acres	$33.33	$ 840,600
	Conservation Buffers	21	acres	$350	$ 7,300
	Streambank Stabilization	12.0	miles	$1,056,000	$ 12,672,000
Big Muddy R. (IL_N-11)	Conservation Tillage	1,567	acres	$33.33	$ 1,044,600
	Conservation Buffers	125	acres	$350	$ 43,800
	Streambank Stabilization	26.1	miles	$1,056,000	$ 27,561,600
	Restrict Livestock Access to Stream	26.0	miles	$21,330	$ 554,600
	Septic Maintenance	97	systems	$250	$ 24,300
Big Muddy R. (IL_N-17)	Conservation Tillage	2,945	acres	$33.33	$ 1,963,100
	Conservation Buffers	58	acres	$350	$ 20,300
	Cover Crops	7,323	acres	$63.16	$ 9,250,400
	Streambank Stabilization	41.7	miles	$1,056,000	$ 44,006,700
	Water and Sediment Control Basins	As needed	acres of land benefitted	$125	$ -
Pond Cr. (IL_NG-02)	Conservation Tillage	2,319	acres	$33.33	$ 1,545,800
	Conservation Buffers	160	acres	$350	$ 56,000
	Cover Crops	5,767	acres	$63.16	$ 7,284,900
	Streambank Stabilization	59.7	miles	$1,056,000	$ 63,005,200
	Water and Sediment Control Basins	As needed	acres of land benefitted	$125	$ -
M. Fk. Big Muddy (IL_NH-07)	Conservation Tillage	10,939	acres	$33.33	$ 7,291,900
	Conservation Buffers	351	acres	$350	$ 122,900
	Streambank Stabilization	134	miles	$1,056,000	$ 141,081,600
Beaver Creek (NGAZ_JC-D1)	Conservation Buffers	25	acres	$350	$ 8,800
	Streambank Stabilization	1.7	miles	$1,056,000	$ 1,774,100
	Water and Sediment Control Basins	15	acres of land benefitted	$125	$ 1,900
Andy Creek (IL_NZN-13)	Conservation Tillage	642	acres	$33.33	$ 428,000
	Conservation Buffers	13	acres	$350	$ 4,700
Middle Fork Big Muddy River (IL_NH-06)	Conservation Buffers	178	acres	$350	$ 62,300
	Restrict Livestock Access to Stream	20	miles	$21,330	$ 426,600
	Septic Maintenance	540	systems	$250	$ 135,000
Herrin Old (IL_RNZD)	Sediment Phosphorus Inactivation	51.3	acres	$1,600	$ 82,100
Johnston City (IL_RNZE)	Sediment Phosphorus Inactivation	64	acres	$1,600	$ 102,400
Arrowhead (Williamson) (IL_RNZX)	Sediment Phosphorus Inactivation	30	acres	$1,600	$ 48,000
	Water and Sediment Control Basins	106	acres of land benefitted	$125	$ 13,300
West Frankfort Old (IL_RNP)	Sediment Phosphorus Inactivation	146	acres	$1,600	$ 233,600

Waterbody	Recommended Management Measures	Quantity	Units	Unit Cost	Estimated Cost
	Conservation Tillage	114	acres	$33.33	$ 76,000
	Conservation Buffers	8	acres	$350	$ 3,000
	Cover Crops	282	acres	$63.16	$ 356,200
	Streambank Stabilization	4.4	miles	$1,056,000	$ 4,678,100
	Water and Sediment Control Basins	1,178	acres of land benefitted	$125	$ 147,300
West Frankfort New (IL_RNQ)	Sediment Phosphorus Inactivation	214	acres	$1,600	$ 342,400
	Conservation Tillage	247	acres	$33.33	$ 164,700
	Conservation Buffers	8	acres	$350	$ 2,700
	Cover Crops	614	acres	$63.16	$ 775,600
	Streambank Stabilization	7.2	miles	$1,056,000	$ 7,645,400
	Water and Sediment Control Basins	1,906	acres of land benefitted	$125	$ 238,300
Total					**$ 336,128,100**

4.6 Potential Funding Sources

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Table 4-8 presents potential funding sources for the recommended controls. This is not an exhaustive source of funding opportunities, but is intended to facilitate the pursuit of funding from applicable sources. Other programs and funding sources may also be available beyond those identified herein. Additional information regarding potential funding sources is provided below.

Table 4-8. Potential Funding Sources for Recommended Conservation Practices

Conservation Practice	Applicable, potential funding sources
Conservation Buffers	Funded under EQIP as field border (386), riparian herbaceous cover (390), or riparian forest buffer (391). Also funded under the Conservation Practices Cost-Share Program.
Conservation Tillage	Funded under EQIP as residue and tillage management, no-till (329). Also funded under the Conservation Practices Cost-Share Program, with some restrictions.
Cover Crops	Funded under EQIP as cover crop (340). Both cover and green manure crops are also funded under the Conservation Practices Cost-Share Program, with some restrictions.
Livestock Management Controls	Funded under EQIP as fence (382) and access control (472).

Conservation Practice	Applicable, potential funding sources
Nutrient Management Plans	Funded under EQIP as comprehensive nutrient management plan (102), nutrient management plan - written (104), and nutrient management (590). Both nutrient management planning and implementation are also funded under the Conservation Practices Cost-Share Program.
Treatment wetlands	Funded under EQIP as constructed wetland (656) and wetland restoration (657). Wetland reserve easements are also available to help protect, restore, ad enhance wetlands through the Agricultural Conservation Easement Program.
Water & Sediment Control Basins	Funded under EQIP as sediment basin (350) and water and sediment control basin (638). This practice is also funded under the Conservation Practices Cost-Share Program.
Streambank Stabilization	The Streambank Stabilization and Restoration Program provides support for low cost techniques to stabilize eroding stream banks.
Watershed Planning	Water Quality Management Planning Grants are available to regional public comprehensive planning organizations and other entities to carry out water quality management planning activities.

4.6.1 Federal Programs

Clean Water Act Section 319 grants[9] to address nonpoint source pollution. Section 319(h) of the Clean Water Act provides Federal funding for states and tribal agencies for the implementation of approved nonpoint source (NPS) management programs. These funds are received and administered by the Illinois EPA. Funding under these grants is used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. This program funds the establishment and management of conservation tillage, cover crops, filter strips, wetlands, and other agriculturally-related BMPs, specifically in watersheds with approved management plans that address reducing nutrient loading to Illinois waters. Of the total project cost, up to 60% can be awarded through the fund. Grantees must provide at least 40% of the costs as an in-kind match or cash. Funds can be used to develop watershed-based plans and for the implementation of watershed-based plans, including the development of information and education programs, and for the installation of best management practices. This is a reimbursement program. Applications are due each year by close of business on August 1st to the Illinois EPA.

Conservation Reserve Program[10] administered by the Farm Service Agency. The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial

[9] http://www.epa.state.il.us/water/financial-assistance/non-point.html
[10] http://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length.

Agricultural Conservation Easement Program (ACEP)[11] This program is administered by the NRCS in Illinois and is a voluntary program offering landowners the opportunity to protect, restore, and enhance agricultural land and wetlands on their property. This program includes the Wetland Reserve Easement Program (WREP). The NRCS provides technical and financial support to help landowners with their restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.

Environmental Quality Incentive Program (EQIP)[12] This program is administered by the NRCS in Illinois and provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. Contracts may last for up to 10 years. Special payment schedules are in place for socially disadvantaged, beginning and limited resource farmers, Indian tribes, and veterans.

Application is a competitive process and EQIP applicants compete for funds by 'funding pool', a process that allows similar applicants to be grouped together for consideration. Payments are set by practice and are provided to the participants after the implementation of activities identified in their EQIP plan of operations. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. As part of the changes contained within the 2014 Farm Bill, the former Wildlife Habitat Incentive Program (WHIP), which provided both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat, was folded in the EQIP program. Additional changes include un-waivable payment limits of $450,000.

Conservation Stewardship Program (CSP)[13] This program is administered by the NRCS in Illinois and assists agricultural producers with the maintenance and continued improvement of their in-place conservation systems. In addition, the program can provide assistance in the adoption of additional conservation practices which address priority resource concerns. These resource concerns can be water quality/quantity, habitat quality, soil quality, air quality, and energy conservation. Two payment types are offered, both on five-year contracts: a supplemental payment for adopting resource-conserving crop rotations, and annual payments for the adoption or installation of new conservation activities or maintenance of existing practices.

4.6.2 State Programs

Partners for Conservation (PFC) Cost-share Program[14] The Illinois Department of Agriculture administers several initiatives through the PFC cost-share program that promotes nutrient management, conservation tillage and the use of cover crops. Conservation practices that are eligible for cost-share

[11] http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/acep
[12] general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/il/programs/financial/eqip/
[13] http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/
[14] http://www.agr.state.il.us/C2000

assistance through PFC include terraces, grassed waterways, water and sediment control basins, grade stabilization structures, crop residue management, cover crops and nutrient management plans.

This program is designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. New programs under this fund must meet two key criteria:

1. They must be voluntary, and based on incentives rather than government regulation.
2. They must be broad-based, locally-organized efforts, incorporating the interests and participation of local communities, and of private, public and corporate landowners.

The Sustainable Agriculture Grant Program administered through this fund is seeking proposals from parties wishing to complete on-farm research or demonstrations, outreach and education, or university research in the area of agricultural sustainability. Up to $20,000 of support is available per grant.

Conservation Practices Cost-Share Program. Another component of Partners for Conservation Fund, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.

Illinois Conservation Reserve Enhancement Program (CREP)[15]. As an outgrowth of the Conservation Reserve Program, CREP pays the owners of environmentally sensitive land an annual rental rate in exchange for ceasing production and implementing conservation practices. CREP is different from CRP in that CREP focuses on the partnership between state and/or tribal agencies and the federal government. As of 2016, there are 126,805 acres enrolled in the Federal CREP program in Illinois at an average rental rate of $212.30 per acre. Approximately 90,990 acres are protected by CREP easements executed by the State (Illinois CREP, 2016). FSA administers the Federal component of CREP as they do for CRP. The Illinois Department of Natural Resources (IDNR) along with the local SWCD administers the State component and also provides technical assistance. Once the Federal CRP contract has expired, the State component of CREP extends the benefits of the established conservation practices through 15 or 35-year extensions, or in perpetuity with a permanent easement. If a landowner chooses to enroll in a permanent easement, they have the option of enrolling and receiving payment on adjacent additional acres, which would not otherwise be eligible for CRP or CREP, due to a lack of cropping history.

Water Quality Management Planning Grants[16]. Grants are available to regional public comprehensive planning organizations and other entities to carry out water quality management planning activities that protect water quality in Illinois. Projects must address water quality issues.

Grant funds can be used to determine the nature, extent, and causes of point and nonpoint source water pollution; develop water quality management plans; develop technical and administrative guidance tools for water pollution control; develop preliminary designs for best management practices (BMPs) to address water quality problems; implement administrative water pollution controls; and educate the public about the impact and importance of water pollution control.

Illinois EPA receives these funds through Section 604b of the Clean Water Act and administers the program within Illinois. The project period is two years unless otherwise approved. This is a reimbursement program.

Streambank Stabilization and Restoration Program (SSRP). The Illinois Department of Agriculture, with assistance from Soil and Water Conservation Districts, administers the SSRP. This

[15] http://www.dnr.illinois.gov/conservation/CREP/ Pages/default.aspx
[16] http://epa.illinois.gov/topics/water-quality/watershed-management/wqmp/grants/index

program, funded through Partners for Conservation, provides support for using low-cost techniques (e.g., rock riffles, stone toe protection and bendway weirs) to stabilize eroding stream banks.

5 Public Engagement, Education and Information

The pollutants of concern are predominantly from non-point sources, including agricultural land used for crop cultivation and livestock management, and implementation of recommended nonpoint source management measures will be completely voluntary. The previous section provided an initial priority ranking of subwatersheds; however, the final ranking should consider public interest in adopting management measures. Wet weather monitoring is strongly recommended to identify specific areas generating higher pollutant loads.

Achieving the pollutant load reduction targets in the watershed will require organized and sustained efforts in public engagement, education and information. Such efforts will create a culture of stewardship, a broad understanding of the need for pollutant control and increase the implementation of management measures to reduce pollutant loads.

5.1 Watershed Group Formation

There is currently no known active watershed group that is active throughout the Upper Big Muddy River watershed. There are a watershed group that is meeting on a regular basis for the Lake Creek and Pond Creek watersheds organized through the Greater Egypt Regional Planning and Development Commission. The NRCS has been active in portions of the watershed in the past, working with some agricultural property owners and others to implement practices to reduce pollutant loads.

It is recommended that an overall watershed group be formed to serve as the primary watershed group in the Upper Big Muddy River watershed. This group could coordinate their efforts with the Lake Creek Watershed Council, but allow for BMP project identification and implementation on a braaoder scale across the watershed. This group should meet to identify whether there are additional stakeholders with an interest in improving water quality, and develop a plan to reach out to these stakeholders. Potential stakeholders may include NRCS, SWCD, Illinois EPA, County Health Departments, Farm Service Agency staff, Greater Egypt Regional Planning and Development Commission staff, local producers, and other interested residents. Functions of a citizen-driven watershed group are numerous, including:

- Provide a forum for like-minded citizens to discuss issues, actions and priorities for the watershed;
- Be a source of watershed information for the public;
- Organize meetings and watershed events;
- Create vehicles for distributing watershed information such as newsletters, blogs, e-mailings and a web site; and
- Solicit donations and obtain grant funding from government agencies and foundations.

This watershed group will likely need to complete the following tasks to help it accomplish its goals:

- Inform the public that a watershed plan has been developed to gain interest in implementing recommended actions.
- Educate the public on the plan and benefits of the plan.
- Develop a web page and social media outlets which are appropriate for their target audience. These should allow the group to provide updates, post callouts for volunteer events, gather and display data, and present progress.

- Create 1-2 page fact sheets or brochures which can be distributed at public meetings and events. This educational material should educate landowners and community members on their opportunities to implement best management practices and the influence these practices may have on their local water quality. It is ideal to have promotional material which is targeted to residential landowners (perhaps including information on septic systems) and agricultural landowners.
- Identify local events where their outreach can have an effective impact on the watershed community. This might be a local festival, a school science fair, a library event, or anywhere where people from the community gather and there is an opportunity to set up a booth or hand out flyers.

This group will want to think carefully about how to cultivate the membership to be sure that all relevant members of the community can be represented. It can be important to have members from many different sectors: agribusiness operators, recreation groups, rural non-farm and farm residents, urban/suburban residents, environmental interests, elected officials, and farmers (both those who own the land they farm and who rent).

5.2 Public Education and Outreach

Group activities should include public education and outreach to inform watershed residents of the problems with in the watershed, share the implementation plan, and to solicit input on controls that stakeholders are willing to implement. Once the core membership has been formed, the watershed group will be well positioned to plan further outreach to the general public. To promote buy-in, the group should be prepared to offer insight into what any member of the community may do to advance watershed health. This could include developing strategic plans for unique watershed users – both by geography and by topic. For example, residents of the reservoir watersheds may want to develop their own group focused on phosphorus load reduction. Livestock producers may want to form a separate group focused on issues unique to livestock production. NRCS staff may be able to share data from past successes in other watersheds, to encourage more wide-spread adoption of measures that have been successful. Group activities should also focus on reaching elected and appointed government officials to educate them on the role that they can play in implementing BMPs within their communities to help improve the water quality in the Upper Big Muddy River watershed. Funding opportunities described in this report should also be shared with interested landowners. Table 5-1 presents details regarding public information and education, and milestones are presented in Section 6.

As is clear from the prior section, the first scheduled task should be to organize and convene a watershed group. A lead organization will need to be identified or organized to convene the group, or as a foundation group to build on, if there is a need to expand membership to reach a diversity of stakeholder groups. This group should meet to identify and reach out to additional stakeholders, and should also begin compiling past reports and information regarding implementation. The first year of implementation should be devoted to solidifying this group, understanding measures already implemented and their success, and beginning the public outreach and education aspects of implementation, as described in Table 5-1. Guidance for subsequent years is also provided in this table.

Table 5-1. Information & Education Plan Start-Up Schedule

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Organize watershed group	General public	Inform the public and local agencies that the group is expanding	Immediately following plan completion	To Be Determined (IEPA, County Health Departments, NRCS, SWCD, agricultural retailer)	Establishment of a watershed group within 1 year of plan completion, including designation of a coordinator or coordinating committee and if desired, development of a logo.	No cost, assuming the coordinator is a volunteer and a volunteer develops the logo (if desired).
Develop a website for the watershed group and link to any partner websites	All stakeholders	Develop a website to keep people informed about watershed issues and opportunities.	Immediately following plan completion	To Be Determined	Establishment of a website and other social media accounts. Website should minimally include information on the watershed, watershed group and goals, the watershed plan, contact information, email addresses, links, downloads, and a calendar.	$500/year for direct costs to establish a new website. This assumes a watershed group member with aptitude for web development can set up and maintain the site for free.
Compile and review information describing previous implementation and planning	Watershed group	Identify where work has been done, and document what's been successful, who was involved and time frame of the work.	Immediately following watershed group formation	To Be Determined (NRCS, SWCD)	Summary of existing documents and past implementation success compiled.	No cost if using existing resources.

Table 5-1 (continued)

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Inform the general public that an implementation plan has been developed for the Upper Big Muddy River watershed to gain interest in implementing recommended actions	General public	Inform the public about the plan and share information on how public may participate in implementation via existing media newspapers, newsletters and social media	Immediately following watershed group formation	To Be Determined (NRCS, SWCD)	Majority of the public in the watershed are well educated on watershed conditions and know who to contact to get involved.	No cost if using existing resources. If desired, flyers and posters could be developed. Approximate costs would be: $34 for 25 brochures Price based on costs to develop a brochure using preset options http://www.fedex.com/us/office/brochure-printing.html $210 for three mounted posters Assumes 3 posters (22" x 28"). Pricing based on http://www.fedex.com/us/office/poster-printing.html
Identify priority locations and actions for years 2-5	Watershed group	Review initial priority ranking of subwatersheds, priority actions, and other factors that may impact ranking (shovel-ready projects, public interest, past success, fund availability, etc.)	Immediately following watershed group formation	To Be Determined (NRCS, SWCD, USEPA, IEPA)	Watershed group agrees on priority actions and locations for years 2-5, that can be funded by available grants, government programs, etc.	No cost if using existing resources

Table 5-1 (continued)

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Educate private riparian landowners along the Upper Big Muddy River and tributaries how to properly manage their land to reduce pollutant loads.	Private land owners along the Upper Big Muddy River and tributary streams	Conduct workshops for riparian land owners that recommend pollutant controls, funding sources, and qualified contractors.	Once every five years	To Be Determined or Consultant (NRCS, SWCD, IEPA)	Private land owners recognize the benefits of watershed controls.	$3,000 per event
Hold an annual watershed tour for elected officials and others interested in watershed activities	Elected officials; all stakeholders	Offer an annual bus tour of the Upper Big Muddy River watershed for elected officials and others to see restoration areas, areas that are in need of improvement and failed projects	Annually	Municipalities, NRCS, SWCD	Elected officials become more familiar with existing and potential restoration projects and learn more about what is/is not working. Decisions regarding future proposed projects are better informed	$2,000 per event
Implement demonstration projects or highlight existing case studies within the watershed	Elected officials; general public; all stakeholders	Use many forms of media to inform the public when and where demonstration projects are implemented (radio, newspapers, social media, websites, etc.)	Immediately following plan completion and when projects are implemented	To Be Determined (NRCS, SWCD)	The majority of the public in the watershed know about demonstration projects, their benefits and where they are located. The public begins to accept and support watershed improvement projects	$5,000/project

Table 5-1 (continued)

Information & Education Action	Target Audience	Information/ Education Component	Schedule	Lead and (supporting organizations)	Outcomes	Cost
Install “Upper Big Muddy River Watershed” signs along major roads in the watershed	General Public	Design and install signs at key points along major roads in the watershed that inform drivers and passengers that they are entering the Upper Big Muddy River watershed.	Following plan completion	Municipalities	Signs will increase the public’s awareness of the watershed boundary, and will alert them to areas that have an impact on water quality in the creek.	$50,000 for fifty signs

6 Implementation Schedule and Milestones

This section describes an implementation schedule for the recommended measures described in Section 4. These should begin in year 2, after the public engagement, education and outreach program described in Section 5 has been initiated. This schedule should be followed concurrently with the monitoring described in Section 7.

6.1 Implementation Priority

Implementation of management measures works well if the area targeted is of a manageable size. In the absence of site-specific information on local partnerships and watershed protection restoration activities within the watershed, the implementation priorities identified in Table 6-1 are generally based on implementing from upstream to downstream in the watershed. This maximizes the impact of management actions taken in the high priority/early implementation since reductions in the upstream loads can also impact the downstream pollutant loads as well.

Table 6-1. Recommended Watershed Implementation Priority

Waterbody/ Segment ID	Recommended Watershed Implementation Priority
Big Muddy R. / IL_N-06	High
Big Muddy R. / IL_N-11	High
Big Muddy R. / IL_N-17	Low
Andy Cr. / IL_NZN-13	Medium
Pond Cr. / IL_NG-02	High
Lake Cr. / IL_NGA-02	High
Beaver Cr. / IL_NGAZ-JC-D1	Medium
M. Fk. Big Muddy / IL_NH-06	Medium
M. Fk. Big Muddy / IL_NH-07	Medium
Herrin Old / IL_RNZD	Low
Johnston City / IL_RNZE	Low
Arrowhead (Williamson) / IL_RNZX	Medium
West Frankfort Old / IL_RNP	Medium
West Frankfort New/IL_RNQ	High

This suggested implementation priority should be reviewed by the watershed group upon formation, and modified as necessary to meet their goals, or to identify areas where there is existing support for early implementation.

6.2 Implementation Milestones

As outlined above, there are several interim milestones that should be evaluated to assess progress as the implementation plan moves forward. With the exception of the initial convening the watershed group, all measureable milestones should be finalized by the group. Achievement of these milestones will assure the watershed group that they are making progress in their role. However, additional criteria should be developed which will specifically document the group's progress at improving water quality. These criteria should be decided by the watershed group after formation, but should include the following elements:

- A defined plan for documenting and tracking pollutant concentrations over time.
- A mechanism for tracking implementation of practices in each watershed, or documenting interest in or commitments to implementing practices for future follow-up.
- A mechanism for including the following concepts in their tracking of water quality:
    - Annual fluctuations in precipitation and/or temperature
    - Appreciable adoption of best management practices
    - The addition or removal of any point source facilities
    - The patterns displayed by the dominant crops in the watershed (was there a drought which impacted the crops ability to accumulate biomass, did the planting occur early or late, etc.)
    - The season and 7-day prior conditions during which the samples were taken
- The target concentrations

The watershed group should acknowledge that it may be difficult to determine progress at an early stage of implementation. As enumerated above, any number of factors may alter the in-stream concentrations on a year to year basis. It may be necessary to plan for a multi-year effort which will allow the longer term collection of data and determination of a long term concentration average.

Implementation milestones proposed for tracking progress toward water quality goals are described in Table 6-2, and assume year one of implementation is in 2019. These milestones should be reviewed by the watershed group leading implementation and adjusted to reflect local knowledge and preferred practices.

Table 6-2. Implementation Milestones for Water Quality

Year	Management Measure Action	Milestones/Measures of Success	Milestone Date
2	Identify candidate sites in high priority watersheds for conservation buffers (157 acres), water and sediment control basins (953 acres), and conservation tillage (2,697 acres) – 50% of implementation targets. Identify potential locations with failing onsite systems.	Viable sites identified, suitable for grant application	End of 2020
2	Establish cover crop practices on 3,190 acres (50% of high priority target), focusing in high priority subwatersheds	Acres of cover crop	End of 2020
2-3	Begin work to establish conservation buffers (157 acres), water and sediment control basins (953 acres), and conservation tillage (2,697 acres) in high priority watersheds implementation targets (half of target)	Acres of conservation buffers established, acres of land controlled with sediment basins, acres of conservation tillage started	End of 2021
2-3	Conduct a streambank erosion inventory to identify locations for streambank stabilization in high priority watersheds.	Completion of streambank erosion inventory in high priority watersheds. Viable sites identified and stream miles to be stabilized	End of 2021
2-3	Conduct an inventory of locations where livestock has access to streams in high priority watersheds	Completion of inventory of livestock stream access locations in high priority watersheds. Viable sites identified and stream miles to be fenced.	End of 2021
3	Communicate with Health Department and landowners with failing systems to develop a plan and identify funding to improve onsite systems.	Development of a plan and identification of a funding source to improve failing onsite systems.	End of 2021
3-4	Perform alum lake treatment for phosphorus inactivation in West Frankfort New reservoir (IL_RNP)	Alum lake treatment for phosphorus inactivation in West Frankfort New reservoir (IL_RNP)	End of 2022
3-5	Begin streambank stabilization in areas identified as having the most severe erosion, ultimately targeting 105 miles in high priority watersheds	Miles of streambank stabilized	End of 2023
3-5	Begin installing fences to restrict livestock access to streams, targeting 100% of sites identified in inventory.	Miles of streambank protected from livestock	End of 2023
4	Identify candidate sites for additional conservation buffers (157 acres) and conservation tillage (2,697 acres) (remaining 50% of target).	Viable site identified, suitable for grant application	End of 2022
4-7	Establish conservation buffers (157 acres), water and sediment control basins (953 acres), and conservation tillage (2,697 acres) in high priority	Stream miles with new conservation buffers acres of land controlled with sediment	End of 2025

Year	Management Measure Action	Milestones/Measures of Success	Milestone Date
	watersheds implementation targets (remaining 50% of target)	basins, acres of conservation tillage established	
4-7	Establish cover crop practices on 3,191 (remaining 50% of high priority target), focusing in high priority subwatersheds	Acres of cover crop	End of 2025
5	Conduct 5-year review of implementation plan and prepare updated plan	Completion of updated implementation plan, based on 5-year review	End of 2023
5-6	Identify candidate sites for conservation buffers (575 acres), water and sediment control basins (1,299 acres), and conservation tillage (11,695 acres) (100% of target in medium priority watersheds).	Viable sites identified, suitable for grant application	End of 2024
7-10	Establish cover crop practices on 141 acres in medium priority subwatersheds (half of target)	Acres of cover crop	End of 2028
5-6	Conduct a streambank erosion inventory to identify locations for streambank stabilization in medium and low priority watersheds	Completion of streambank erosion inventory in high priority watersheds. Viable sites identified and stream miles to be stabilized	End of 2024
7-8	Perform alum lake treatment for phosphorus inactivation in Arrowhead (Williamson) (IL_RNZX) and West Frankfort Old (IL_RNP) reservoirs	Alum lake treatment for phosphorus inactivation Arrowhead (Williamson) (IL_RNZX) and West Frankfort Old (IL_RNP) reservoirs	End of 2026
7-10	Establish conservation buffers (575 acres), water and sediment control basins (1,299 acres), and conservation tillage (11,695 acres) in high priority watersheds implementation targets	Acres of conservation buffers established, acres of land controlled with sediment basins, acres of conservation tillage	End of 2028
7-10	Begin streambank stabilization in areas identified as having the most severe erosion, ultimately targeting 140.1 miles in medium priority watersheds	Miles of streambank stabilized	End of 2028
7-10	Establish cover crop practices on 141 acres in medium priority subwatersheds (remaining 50% of target)	Acres of cover crop	End of 2028
10	Conduct 5-year review of implementation plan and prepare updated plan	Completion of updated implementation plan, based on 5-year review	End of 2028
11-14	Begin streambank stabilization in areas identified as having the most severe erosion, ultimately targeting 42 miles in low priority watersheds	Miles of streambank stabilized	End of 2032
11-14	Establish conservation buffers (58 acres) and conservation tillage (2,945 acres) in low priority watershed implementation targets.	Acres of conservation buffers established, acres of conservation tillage	End of 2032

Year	Management Measure Action	Milestones/Measures of Success	Milestone Date
11-14	Establish cover crop practices on 7,323 acres in low priority subwatersheds	Acres of cover crop	End of 2032
15	Perform alum lake treatment for phosphorus inactivation in Herrin Old (IL_RNZD) and Johnston City (IL_RNZE) reservoirs	Alum lake treatment for phosphorus inactivation Herrin Old (IL_RNZD) and Johnston City (IL_RNZE) reservoirs	End of 2033
15	Conduct 5-year review of implementation plan, progress towards water quality targets, and prepare updated plan	Completion of updated implementation plan, based on 5-year review.	End of 2033

These are long-term goals, recognizing the need for a local watershed group to be established, educated, secure funding and partnerships, and begin implementation of BMPs. These goals will need to be modified by the watershed group as they begin implementation to meet their locally established priorities.

7 Monitoring

A monitoring program should be implemented to measure progress in applying the recommended management measures and tracking water quality improvements. Illinois EPA conducts a variety of lake and stream monitoring programs, including: a statewide Ambient Water Quality Monitoring Network (AWQMN); an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program.

The Illinois EPA Southern Monitoring Unit currently samples two waterbodies in the Upper Big Muddy River watershed under the AWQMN; the Middle Fork Big Muddy River at station NH-06, and the Big Muddy River at station N-11. These stations are sampled nine times per water year (a water year runs from October 1 to September 30) on an approximately six-week cycle.

Illinois EPA is scheduled to perform additional sampling in the Upper Big Muddy River watershed as part of the 2018 Intensive Basin Survey. This watershed will likely be sampled again in 2023, as part of IEPA's five-year rotating schedule. Monitoring by Illinois EPA under this program will provide information on the change in pollutant concentrations over time, reflecting improvements following implementation of management measures.

The watershed group should encourage IEPA to monitor additional locations during the 2023 Intensive Basin Survey, in particular adding locations within the priority watersheds to monitor the progress towards meeting the target pollutant load reductions.

Additional monitoring is also recommended to supplement data collected by Illinois EPA. It may be possible that sampling can be conducted by volunteers to reduce costs. Local sewage treatment plants could be contacted to see if they are willing to donate laboratory analytical services. Prior to monitoring, it is recommended that a Quality Assurance Project Plan (QAPP) be developed. If external funding for monitoring is required, the watershed group will need to identify funding sources potentially from USEPA grant programs. Once funding is secured and the monitoring points identified, the watershed group will conduct the sampling. The frequency of sampling and number of sampling locations will depend on available resources. The group should plan to interface with IEPA about sampling events within the watershed to help them assess pollutant load reductions. The recommended schedule for setting up the watershed monitoring to track progress towards TMDL/LRS implementation is shown in Table 7-1.

Table 7-1. Watershed Monitoring Schedule

Year	Action	Notes	Milestones/Measures of Success
1	Plan sampling; line up laboratory analysis services	Sampling should include total and dissolved phosphorus, total suspended solids, fecal coliform, total iron, and manganese; plan should include sampling locations map	Written plan
1	Prepare QAPP	Illinois EPA can provide examples	Written QAPP
1	Present sampling plan to public; seek volunteers	The sampling plan should be presented at the first annual public watershed meeting	Public meeting with sampling plan presentation
2	Prepare sampling schedule	Based on volunteer availability and availability of laboratory resources, plan sampling schedule	Sampling schedule posted to web site

Year	Action	Notes	Milestones/Measures of Success
2	Seek supplemental funding	If needed, apply for grants to support sampling program	Grant(s) for supplemental funding
2	Conduct sampling	Collect samples as planned	Completion of sampling event(s) by local watershed group
2	Evaluate results; review program; determine need for changes	Identify successes, problems, challenges from initial sampling; revise plan accordingly	Revised sampling plan
3-15	Implement sampling program	Review program every year and identify new resources, areas for improvement. Results should be evaluated for trends over time, as well as compared to target pollutant concentrations to determine whether goals have been attained.	

7.1 Stream Monitoring

Supplemental sampling for streams during the implementation of the TMDLs and LRSs to track progress towards the pollutant reductions and improvements in water quality. A minimum of monthly sampling at stream stations shown in Table 7-2 in years when Illinois EPA does not conduct sampling at those stations. Both low and high flow conditions should be targeted over the course of the year, targeting to sample during at least 3 wet weather impacted flow events annually, since all of these TMDLs and LRSs have runoff related sources.

Table 7-2. River/Stream Monitoring Stations

Waterbody/ Segment ID	Monitoring Stations
Big Muddy R. / IL_N-06	N-06, N-10
Big Muddy R. / IL_N-11	N-11
Big Muddy R. / IL_N-17	N-17
Andy Cr. / IL_NZN-13	NZN-15
Pond Cr. / IL_NG-02	NG-02, NG-05
Lake Cr. / IL_NGA-02	NGA-02
Beaver Cr. / IL_NGAZ-JC-D1	NGAZ-JC-D1
M. Fk. Big Muddy / IL_NH-06	NH-06
M. Fk. Big Muddy / IL_NH-07	NH-07

Annual sampling will provide more frequent data which will help identify temporal trends, as well as patterns related to weather. In addition, more frequent data will allow better discernment of the impacts of management measures as they are implemented.

Additional sampling locations could be added to create a richer data set to assess water quality in streams and may provide a means to better observe the effects of management measures by providing upstream/downstream sampling pairs. During implementation planning for each subwatershed, it is recommended that the watershed group identify additional locations for sampling stations that could be used to monitor water quality.

Stream sampling should include fecal coliform, and total suspended sediment. Where possible, flow measurement should be conducted as a component of stream monitoring, particularly on the tributary streams and the Middle Fork Big Muddy River, since the USGS gage located at station N-11 on the Big Muddy River is impacted by the release of flows from Rend Lake.

7.2 Lake Monitoring

IEPA has historically sampled each of the reservoirs in the watershed at 3 locations. Lake sampling should include measurements of total phosphorus concentrations at these locations for comparison to past data for trend assessment. Monitoring in the tributaries draining to the lakes has not been conducted in the past, but could also be initiated near the point where the streams enter the lakes, to characterize the phosphorus concentrations entering the lakes.

Table 7-3. Lake Monitoring Stations

Waterbody/ Segment ID	Existing Monitoring Stations
Herrin Old / IL_RNZD	RNZD-1, RNZD-2, RNZD-3
Johnston City / IL_RNZE	RNZE-1, RNZE-2, RNZE-3
Arrowhead (Williamson) / IL_RNZX	RNZX-1, RNZX-2, RNZX-3
West Frankfort Old / IL_RNP	RNP-1, RNP-2, RNP-3
West Frankfort New/IL_RNQ	RNQ-1, RNQ-2, RNQ-3

A map showing the current monitoring stations in the watershed is shown in Figure 7-1. Within each of the lakes, the monitoring locations are generally located near the dam at the downstream end, in the middle of the lake, and near the upstream end to capture the spatial variability in the water quality conditions.

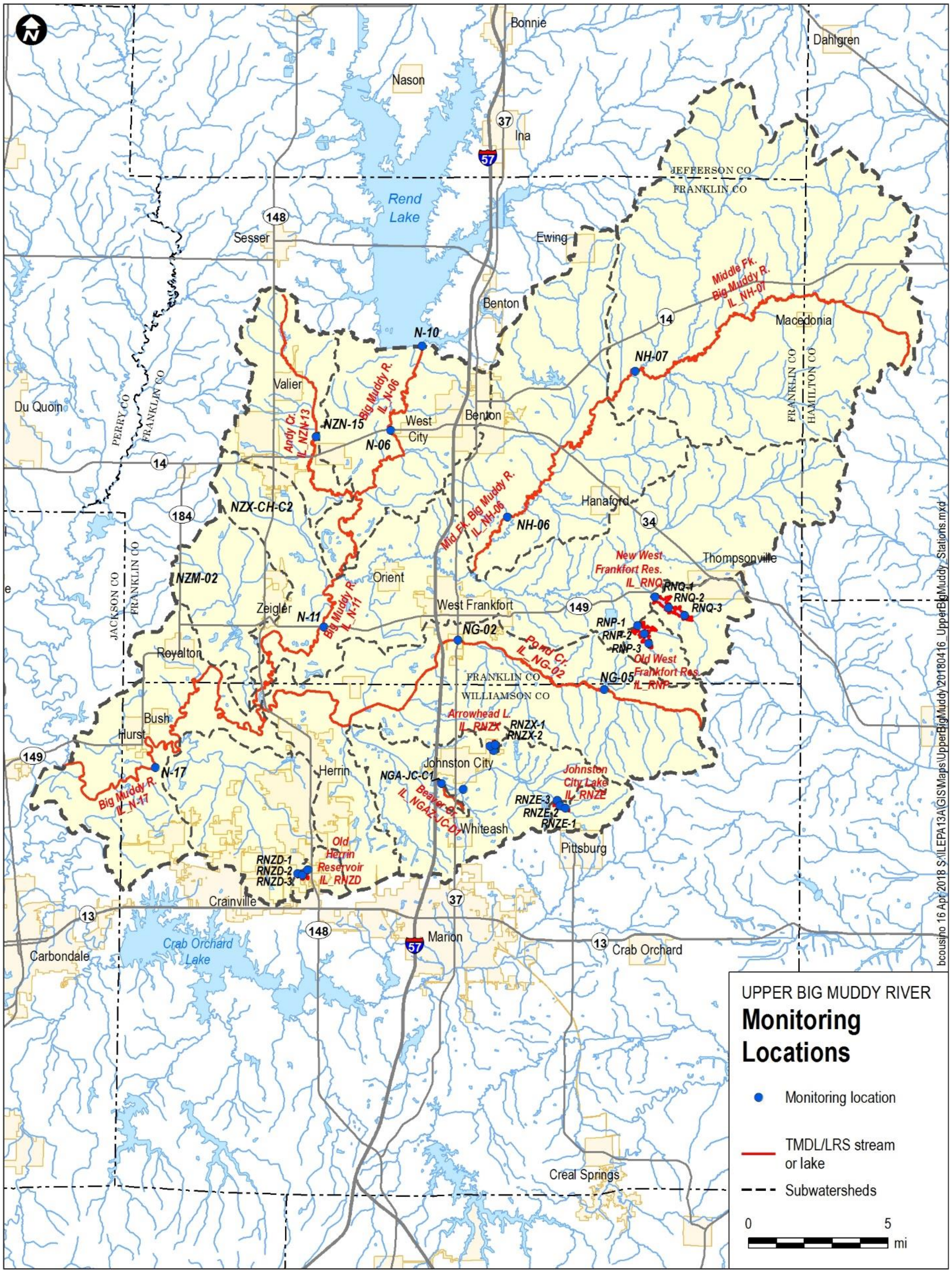

Figure 7-1. Upper Big Muddy River Monitoring Locations

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